S. Hrg. 99-698

NATIONAL SCIENCE FOUNDATION AUTHORIZATION ACT FOR FISCAL YEAR 1987

HEARING

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

ON

S. 2184

TO AUTHORIZE APPROPRIATIONS TO THE NATIONAL SCIENCE FOUNDATION FOR THE FISCAL YEAR 1987, AND FOR OTHER PURPOSES

MARCH 26, 1986

Printed for the use of the Committee on Labor and Human Resources

U.S. GOVERNMENT PRINTING OFFICE
61-232 O WASHINGTON : 1986

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

5541-60

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NATIONAL SCIENCE REAUTHORIZATION ACT FOR FISCAL YEAR 1987

WEDNESDAY, MARCH 26, 1986

U.S. SENATE,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:45 a.m., in room SD-430, Dirksen Senate Office Building, Senator Orrin Hatch (chairman of the committee) presiding.

Present: Senators Hatch, Simon, Kerry, Pell, and Dodd.

Senator SIMON (presiding pro tempore). The hearing will come to order.

Senator Hatch is going to be here very shortly, and it has been suggested that I go ahead and open the hearing.

Our first witness is Mr. Erich Bloch, Director of the National Science Foundation. We are very happy to have you here, Mr. Bloch.

Senator Kerry, do you have an opening statement?

Senator KERRY. I think I will wait, Senator, until after the testimony, and then I might make a statement. However, I will submit my prepared statement for the record at this time.

Senator SIMON. Fine. Thank you. Also, at this time we will receive for the record the opening statement of Senator Hatch as well as statements from Senators Hawkins and Kennedy.

[Statements of Senator Hatch, Hawkins, Kennedy, and Kerry follow:]

OPENING STATEMENT OF SENATOR ORRIN G. HATCH

Senator HATCH. For the last 35 years, the National Science Foundation [NSF] has supported basic research which has contributed to the development of important new technologies and, ultimately, to increased productivity and a higher standard of living for all of us. Although the NSF is a small part of the total national effort in research and development, it is the primary source of support for basic, fundamental scientific and engineering research as well as for the science and mathematics education in our Nation's schools.

The key role of scientific and technological innovation in increasing productivity in our economy has been well documented. In the post World War II decades, new technology was responsible for nearly half of all productivity gains. NSF's support for research in the various fields of science and engineering has been instrumental in advancing these innovations.

However, while productivity in the United States remains higher in absolute terms, it has declined relative to that of other countries such as Britain, France, Germany, Japan, and Korea. From 1973 to 1983 U.S. productivity rose at the annual rate of only 0.3 percent. The annual gain for Korea was 15 times that, or 4.5 percent. Productivity in Japan rose at a rate of 2.7 percent, while France and Germany's rose 2.1 percent, and Britain's rose 1.5 percent.

In order for us to compete internationally, we must continue to support the basic research and education activities of the NSF which will guarantee the base for future development as well as the supply of American scientific and engineering "brainpower." This is no time to stop supporting research.

The administration's concern over these economic realities is reflected by its recommendations for a moderate increase in funding for the NSF this year. This increase, which amounts to 5 percent in real terms and 3 percent over pre-Gramm-Rudman-Hollings fiscal year 1986 levels, is an investment in the future and economic well-being of our country.

While we are necessarily constrained in our ability to spend as much as we might like to support basic research and math-science education programs, we cannot overlook their importance to our Nation's future.

I would like to welcome Erich Bloch, the Director of the National Science Foundation, who is with us today to testify. We want to acknowledge the fine work he has done managing the NSF and his leadership in science and engineering research and education.

STATEMENT OF SENATOR PAULA HAWKINS

Senator HAWKINS. As we consider funding for the National Science Foundation for fiscal year 1987, I believe it is important to remember the special role that NSF has in the Federal support of science and engineering research and education. NSF provides a very small portion of the total Federal dollar expended on research and development. However, it provides approximately one-quarter of the support for basic research at colleges and universities.

Many R&D programs focus on specific projects or goals. The NSF promotes basic research, and supports promising new ideas in any field of science and engineering. Moreover, the NSF has the important role of attracting young people to science and engineering. This is essential if the United States is to continue to maintain the respect that it now enjoys within the world's scientific community.

Clearly, the administration recognizes the significant role NSF holds in assuring that the United States continues its leadership in scientific and engineering fields. I commend the administration's proposed increase in the 1987 budget request, compared to 1986.

The payoffs from basic research are tremendous and have in the past contributed to major growth in the marketplace. New ideas yield new products. The basic research that NSF supports, should have our support.

STATEMENT OF SENATOR EDWARD M. KENNEDY

Senator KENNEDY. It is a pleasure to be here today. Science enhances our understanding of the world around us and it enables us to improve the way we live. It allows us to protect ourselves against natural and manmade dangers, and it provides the basis for our success in the international economic arena.

The National Science Foundation has a crucial place in the scientific structure our our country. Though it represents a small percentage of the entire research budget, it is the seed from which many of our scientific endeavors grow. Unless conditions are right, the tools are adequate, and scientific research activities are properly nurtured, what grows from this seed will not be adequate to the task of keeping this great Nation moving forward.

This is a particularly exciting period in the history of scientific discovery. There are many projects which are already underway which will give us the opportunity to take giant steps toward a better future. The methodological tools and technology of scientific research have been vastly expanded. Biotechnology, supercomputing, communications technologies, and many other new techniques provide the basis for advances which could be sustained at a rate previously unimagined. The United States has led the world in these advances. But other enterprising countries are beginning to rival our accomplishments. We cannot default on the commitment we have made to remain at the forefront.

Only highly educated and carefully trained scientists, technicians, and managers will allow us to maximize the potential of our existing expertise. We must pay careful attention to the area of scientific education and training. In the last decade, there has been an alarming decline in the number of young Americans seeking degrees and careers in science and engineering. This will not improve unless support for education in these areas improves. We must continue to focus on this problem.

The potential benefits of careful investment of activities of the National Science Foundation are unlimited. Only careful planning and wise use of resources will allow us to maximize this investment.

STATEMENT OF SENATOR JOHN KERRY

Senator **Kerry**. Mr. Chairman, I am pleased that the Committee on Labor and Human Resources is holding this hearing today to consider reauthorization for the National Science Foundation. America's leadership in science and technology is crucial to maintaining a strong competitive posture in the international economy of the future. NSF plays a very important role in supporting basic research in science and science education, which makes our position of leadership in science and technology possible. I believe that there is no more critical issue for the future of this Nation than the question of how we maintain our tradition of excellence in science and technology, and thus our ability to compete in world markets, in the changing and highly competitive environment of the new international economy.

I am concerned that the current administration has not placed sufficient emphasis on the importance of nurturing basic civilian research in science and on science education for the future, especially at the precollege level. I am additionally concerned because the President is now without a full-time, permanent scientific adviser, who can represent the scientific community at the highest level of Government. I have expressed these concerns publicly in a recent letter to the editor of Science magazine.

It is no secret to anyone in the scientific community that, in the past few years, the role of the President's science adviser has changed from that of a representative of the scientific community, to that of a proponent of the President's policies, such as the Strategic Defense Initiative. Such a politicization of the role of the Presidential science adviser is undesirable and counterproductive. It is my hope that we will soon see a Presidential science adviser able to represent the interests of science policy and the scientific community, as well as the use of science for policy.

Several recent trends in U.S. science and technology lend a sense of urgency to my concerns. I would single out four areas of particular concern.

First is the eroding base of our university research enterprise. Some of our brightest investigators are being forced to work with outdated equipment in antiquated facilities. Construction and renovation of academic research facilities could amount to from $5 billion to $20 billion over 10 to 20 years according to some estimates. Costs for closing the gap between present university instrumentation and that required to ensure maximum productivity from creative and innovative researchers may alone be as much as $1 billion. In the face of this need, however, we have seen Federal obligations for academic research and development plants decrease by 90 percent—in constant dollars—between 1966 and 1983.

Second is the direction R&D spending has taken during the last two decades. Primary in the significant rise in R&D expenditures over the 1982-86 period has been the major increase in Department of Defense [DOD] R&D support. One major factor has been the rapid increase in funding for the Strategic Defense Initiative [SDI]. NSF director Erich Bloch, who is with us today, recently emphasized that only a little more than a quarter of all Federal R&D effort goes into civilian research. Indeed, United States civilian R&D as a percentage of gross national product is now below that of Japan and West Germany. Moreover, as Dr. Bloch also noted, DOD funds are largely directed to shorter term development efforts, with roughly only 3 percent going to basic research.

Third is the growing importance of science and technology to economic health, to developing new products, to creating new jobs and to increasing productivity. This has been dramatically demonstrated in my own State of Massachusetts, where our blends of mature industries and high technology enabled the State to weather the recession of the early 1980's and emerge into a period of economic growth.

And fourth is the fact that we stand at the threshold of many exciting developments in fields such as biotechnology, advanced materials, microelectronics, and supercomputers. We need to take steps to maintain our position of leadership in these areas. Without support from Government, America's high technology industry is in danger of falling behind those of Japan, Europe, and the Soviet Union.

Certainly, now more than ever, it is important for the President to have a science adviser who will be an active, truly representative voice for all of science in our Government. Today, our national security strongly depends upon our ability to compete in international markets. That ability in turn depends upon a sound research base, able to fuel the technology and innovation needed to sustain our economic leadership. In order to maintain our position of leadership, we need strong support for science in the Congress, and from the President.

In this context, I am encouraged that, as Dr. Bloch points out in his statement submitted for this hearing, Federal support of basic research is estimated to increase by 8 percent in fiscal year 1987. However, as Dr. Bloch also points out, the share of research dollars that is devoted to basic research is dropping. This is a disturbing trend, in light of the concerns I have stated.

I am in full agreement with Dr. Bloch that investment in basic science and engineering is essential to improving our international competitiveness, and to reducing the trade deficit. It is indeed true that from our history of support for basic research at America's colleges and universities has come America's history of scientific excellence, technological preeminence, and our many Nobel prizes in science. I also agree with Dr. Bloch that we need to strengthen support of basic research in science and engineering, that we need to attract more young people to science and engineering, and that we need to make greater investment in the infrastructure of science and engineering—equipment, instrumentation, and facilities.

The last point is of particular concern, because of the shortsighted nature of this administration's policies with regard to indirect costs incurred by universities with respect to research grants. Recent proposals drafted by the Office of Management and Budget, contained in directive A-21, could reduce payments to academic institutions by $100 million this year, and more than $200 million in fiscal year 1987.

Robert Rosenzweig, president of the Association of American Universities, has aptly described these proposals as "arbitrary and capricious." These proposals are scheduled to take effect on April 1, less than 6 weeks after they were made public. This is a totally inadequate procedure which does not allow for adequate comment and consideration by those who are most directly affected by these proposals. As Rosenzweig has pointed out, the OMB has abandoned any pretense of working out a mutually acceptable arrangement with the universities. Items and services paid for by indirect costs are an integral part of the research enterprise. The infrastructure of science is what makes good science possible. At a time when other nations such as Japan and West Germany are investing in scientific research for the future, no policy on our part could be more shortsighted than the one currently being promulgated by this administration.

I am glad that Dr. Bloch, in his statement, has taken note of the fact that, under President Reagan, America has gone from being a creditor nation to a debtor nation, and one with a growing trade deficit. As he points out, trade protectionism is not the answer to this problem—developing new technology is the only real solution. My own State of Massachusetts has been a leader in the development of new high-technology industry. This is due in large part to the spinoff effect from over 100 colleges and universities located in Massachusetts, including such world-renowned institutions as Harvard and MIT. I am pleased to note that NSF has made an award to MIT to establish a Center for Biotechnology Process Engineering. Joint university-industry partnerships in research are very important to encourage innovation in technology, and continuing the trends which were started along Route 128 in Massachusetts.

I would also commend Dr. Bloch for his emphasis on increasing the participation of women, minorities, and the disabled in science and engineering. As Dr. David Hamburg has pointed out in his statement submitted for this hearing, one of the most fundamental issues in education today is the question of how we can give all of our children, regardless of social background, a good opportunity to participate in the modern technical world. We must make greater efforts to link the science-rich and science-poor sectors of our society. Women and minorities are greatly underrepresented in science and engineering in the United States. We need to broaden the pool of scientific talent in this Nation, both in the interest of equal opportunity, and in the interest of science.

We have in the United States the largest and most respected scientific community in the world, yet our precollegiate science education is at a low ebb. We must connect the scientific talent of our universities, colleges, corporate laboratories, and national laboratories with the elementary and secondary schools, thereby strengthening the national capacity for broad education in the physical, biological, and behavioral sciences.

I was gratified to note a recent article in Science magazine headlined "Education Makes Comeback at NSF." The decision of the Reagan administration in 1981 to abolish NSF's science educational directorate was unquestionably shortsighted and a serious mistake. I am pleased that the administration has now corrected the error of its ways, and is now proposing an $89 million Science Education Program for NSF, which includes a $2 million increase over the current year. I am aware that there is some sentiment among certain of my colleagues that this amount should be reduced, perhaps by as much as $10 million in fiscal year 1987. In my view, this would be a serious mistake. Science education is an investment in the future, an investment which we must make now if we are to remain competitive in the world economy in the years ahead. But I would also caution NSF that, if they are to come to us with a request for increased funding for science education, they must make greater efforts to make good use of the funds which are appropriated for this purpose. I am aware that, for the past several years, NSF has not spent the money made available to it by the Congress for precollege science and mathematics education. Surely, when we look at the efforts that the Soviet Union is making in this area, we must recognize that science education on the elementary and secondary school level is an urgent national need. No other entity, public or private, can replace the NSF in science education.

Leadership in science and technology is critical to our future as a nation. Support for science in government is essential if we as a nation are to remain competitive in the world economy in the future. The National Science Foundation has a crucial role to play in ensuring that the United States retains its traditional position of leadership in science and technology. We can no longer take this position for granted. While I am encouraged by the support for science indicated by increases in the NSF budget for fiscal year 1987, I am also mindful that the trends which I have outlined give rise to serious cause for concern about the direction that U.S. science and technology is taking. I hope that today's hearing will be only the beginning of a process of address these concerns, so that America may remain the world's leader in science and technology.

Senator SIMON. Mr. Bloch, you may proceed.

STATEMENT OF ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Mr. BLOCH. Thank you, Senator.

I have a prepared statement that with your permission, I would like to submit for the record.

Senator SIMON. It will be entered in the record.

Mr. BLOCH. Thank you.

I also have a statement that was prepared by Dr. Roland Schmitt, the Chairman of the National Science Board, who is sorry that he cannot be here today; and I would also like to introduce that into the record.

Senator SIMON. That will be entered in the record.

Mr. BLOCH. Thank you.

I would like to take a few minutes to summarize the reasons why it is important to support the President's budget request for the National Science Foundation for fiscal year 1987.

Mr. Chairman, there are three reasons why the Federal Government supports research and education in the science and engineering. They are, first of all, for its intrinsic intellectual value; second, because Government needs the results of that research, and third, for economic competitiveness.

The Foundation has long been dedicated to the first reason, intrinsic intellectual value, and the Congress has long supported this quest to do the best possible science in every field. We will continue to support excellence in pursuit of this goal.

The second goal is to create new knowledge that Government itself needs in support of specific missions, such as defense, health, or agriculture. This is principally the concern of mission agencies, but not solely.

I will concentrate my remarks this morning on the third goal, that of economic competitiveness. This is the area in which the nation is most in need, an area in which the National Science Foundation has much to offer, and it is the rationale behind our major budget thrusts for this year.

It is no secret that the world has become a much more competitive place in recent years. I would like you to consider a number of facts. Please turn to the first chart handed out to you.[1] It shows that our trade balance is overwhelmingly negative; that is nothing new, it has been so for a number of years. But even the advantage in the high-technology products areas, that you see on top of that chart, and that we once took for granted, has eroded away to the point where we will show a zero balance instead of a positive balance of trade, in the next couple years or so.

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[1] The charts referred to in text appear at the end of Mr. Schmitt's prepared statement.

In both high- and low-technology products, the markets in which we must compete are increasingly international. The company that is first in the market with the most technically advanced product, at the best price, is the one that will succeed.

Research provides the underlying base for the new products that we need to compete in high-technology areas. The process improvements that can raise productivity in the low-technology manufacturing and service industries also flow from high-technology research.

Chart 2 shows that, in quantitative terms, it is technology innovations created through research, that have been responsible for nearly half of all productivity gains since World War II, and in fact, on this particular chart, it is the biggest factor that contributes to productivity increases.

Many of the NSF programs support this process of innovation—robotics, the engineering research centers, biotechnology, materials research, the education of future scientists and engineers, and many more. Research is the right way to enhance our international competitiveness and is preferable to reliance on trade barriers and other protectionist measures.

The science and engineering base on which we depend consists of three elements: people, facilities, and equipment. Of the three, people are by far the most important. Facilities and equipment are relatively short leadtime items. People, however, come only through a long process of education. For a scientist or engineer, the process begins in junior high school and continues through undergraduate and graduate training—in all, a dozen years or more.

The length of the pipeline makes it imperative that we have a continuous flow of the most talented young students in science and engineering programs. This must be done through conscious policy. We cannot depend on market demand alone to ensure that we will have the necessary numbers, because the educational system cannot respond rapidly when demand fluctuates and changes.

Therefore, as our society becomes more and more dependent on technology, we must be sure that we do three things: first, educate enough new scientists and engineers; second, support basic research adequately; and third, invest sufficiently in research facilities and equipment.

On chart 3 you can see how we compare to our trading partners in investment in research. The United States has not invested in R&D in recent decades at a necessary rate to sustain the growth required for a modern technological society. We have slipped from the position of leadership we held 20 years ago, while our competitors have been pushing ahead in an effort to challenge and surpass us in key technology areas.

Furthermore, if you turn to chart 4, the proportion of our R&D that goes for defense has been both high and rising. And when we consider only civilian-oriented R&D, which is the most applicable to economic development, we find that our level of effort is behind that of West Germany and Japan by a significant amount.

An encouraging trend, however, as you see on chart 5, is the fact that our Federal expenditures for civilian R&D are increasingly for basic research. Development expenditures are quite properly being left to industry. This chart shows that, over the last 4 or 5 years in particular, the non-DoD basic research effort has increased significantly, while that of DoD has decreased.

Is there an optimum level of support for basic research? This is a difficult question to answer, and there is no simple numerical answer to the question. But when we see that basic research is dropping as a proportion of total Federal support, as you can see on chart 5 in the middle, and we see increasing competition from our trading partners, as I showed a few minutes ago, and we see shortages of scientists and engineers developing, which I will talk about in a second and we all agree that facilities and instrumentation in universities are in deplorable condition, then we can only conclude that we are underfunding basic research, especially basic research in universities.

Let me turn to the people problem which has occupied this committee's attention extensively in the past. As our society becomes more dependent on technology, we will need more of our population educated in science and engineering. The consequence of underfunding basic research, however, is that we are attracting too few young people to these areas. If you turn to chart 6, you see that 20 years ago the United States had far more scientists and engineers per capita than any of our competitors. Today, that is no longer the case. And the proportion of our young people who are being attracted to scientific and engineering programs is declining as a percent of the population.

[Chart 7 was not addressed.]

On our next chart, No. 8, you see what happens as the 22-year-old cohort drops as a percentage of the total population. We clearly see that there might be a shortfall over the next 20 years in production of scientists and engineers, if we assume that the same rate of people enter these professions as they did in 1983 and the same requirement exists as in 1983.

Increasingly, we are dependent on foreign nationals for new Ph.D's in engineering, as shown on chart 9. This is true not only in engineering, but also in mathematics, and it is becoming increasingly true in physics, the most critical disciplines of a technological society. While we benefit from this trend since many of these students stay here and join the work force—about 48 percent—we have, however, an overdependence on a resource that is not under our control and that can be shut off at a moment's notice.

This committee has done a great deal to provide national leadership to deal with this problem of education. The mathematics and science education activities enacted through your efforts have helped NSF build a solid program. We are meeting the functional objectives specified in the legislation, through programs that enhance public understanding of science and technology; by developing science and engineering faculty; by enhancing teacher training; by recruiting underrepresented groups such as women and minorities; by developing better curriculum materials, and also by doing research on the education process itself.

We have been through a period of great change in our science education program, as you can see on chart 10. As a result, we now focus on precollege education, the black colored area on the chart, and on fellowships. Precollege is a critical period in which interest in science and engineering is being deeply developed, and that is why our programs focus on precollege education.

I want to say one more word about people. Through all of our granting mechanisms, we are affecting a large number of people. We are affecting about 13,000 senior scientists, about 3,600 postdoctorates, about 14,000 graduate students, and about 4,500 undergraduate students.

Let me talk next about undergraduate education. There will be more emphasis on this subject throughout the Foundation in the future. A special committee of the National Science Board has just completed action on a new report on the Foundation's role in undergraduate science education. The report is being released today, and we will make it available to you and the committee. I would like to share some major conclusions with you now.

The Board committee's report found several major deficiencies in American undergraduate education in mathematics, in science and in engineering: first of all, inadequate laboratory instruction and inadequate laboratory equipment; second, faculty members who are not up to date on the state of the art; and third, unimaginative, outdated, and inaccurate courses and curriculum materials.

The report notes that the primary responsibility for education, as we will all agree, must rest with the State, local, and private institutions. Neither the Federal Government nor the National Science Foundation should take financial responsibility for the totality of undergraduate education.

However, there are many ways the Foundation can help. The most important way is to develop the links between researchers and undergraduate educators. We can do this by getting faculty in undergraduate institutions involved with research projects in larger universities; by making opportunities for advanced undergraduates to take part in research; by increasing the support for research and instrumentation in predominantly undergraduate institutions—since 1983, NSF support of these institutions has been rising from about $28 million to an estimated $54 million in 1987—and by providing undergraduate schools with instructional scientific equipment.

Besides these continuing effects that are in the 1987 budget base amounting to more than $54 million, another special initiative entitled, "Broadening Participation in Science and Engineering", adds about $13 million to that base in 1987 for new activities such as faculty research development in undergraduate institutions and student opportunities in research.

I will say one more thing about facilities. The Federal investment in academic research facilities has declined by almost 95 percent since 1965. The programs that once strengthened our university infrastructure no longer exist and have not existed over the last 20 years, and I think we see the results of that today.

The NSF investment in research instrumentation is up dramatically and consciously over the last 5 years, as you can see on your last chart, No. 11. In 1987, we also have a significant increase planned for the instrumentation area. I think that helps a great deal, rejuvenating some of the laboratories and providing some of the equipment for research that is needed for forefront science and engineering; but we have a long way to go.

The backlog of investment dollars needed in academic research facilities and instrumentation is not known, but it is clearly in the multi-billion-dollar range.

In summary, Mr. Chairman, the strongest case that I can make for the support of the President's budget request for the National Science Foundation is that we must begin to do something about the trends that I have just outlined. It is encouraging that even in a time of great austerity in Federal funding, the administration has recognized the need for an increase in our budget. The proposed increase will go where it will do the most good—to support basic research and education in the fields most critical to our economic competitiveness.

We have four areas of special emphasis that are outlined in my full statement: biotechnology; computational science and engineering; global geosciences; and broadened participation in science and engineering. Each of these areas of concentration is focused directly on our economic problems. The first three are critical research areas in which the new knowledge can be the basis for expanded industrial and economic activity that will repay our investments richly in employment and wealth. The fourth area is aimed at providing the people that we must have who must increasingly be recruited among women, minorities and other groups that have not participated fully in science and engineering.

Mr. Chairman, I would like to leave you with one thought: Investment in science and engineering research and education has been the source of much of our economic progress in the last four decades. It continues to be the best single way that we can provide the jobs and the national welfare that we must have in the future. I urge you to ensure that we have the resources necessary to meet this challenge.

Thank you very much.

[The prepared statements of Mr. Bloch, Dr. Schmitt, and the charts referred to in the text follow:]

National
Science
Foundation

STATEMENT OF
MR. ERICH BLOCH
DIRECTOR, NATIONAL SCIENCE FOUNDATION
BEFORE THE
COMMITTEE ON LABOR AND HUMAN RESOURCES
U.S. SENATE
MARCH 26, 1986

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

IT IS A PLEASURE TO MEET WITH YOU TODAY TO DISCUSS THE FY 1987 BUDGET REQUEST FOR THE NATIONAL SCIENCE FOUNDATION. I WANT TO THANK YOU FOR THE SUPPORT WHICH YOU GAVE TO THE FOUNDATION'S BUDGET LAST YEAR, BUT PARTICULARLY I WOULD LIKE TO COMMEND YOU AND YOUR SENATE AND HOUSE COLLEAGUES FOR GETTING AN AUTHORIZATION BILL PASSED AFTER A HIATUS OF SEVERAL YEARS.

I'D LIKE TO TAKE THIS OPPORTUNITY TO SUMMARIZE AND HIGHLIGHT OUR STRATEGY, THE PROBLEMS WITH WHICH WE ARE FACED, AND THE SPECIAL OPPORTUNITIES WHICH OUR BUDGET REQUEST INCLUDES.

MR. CHAIRMAN, I WANT TO FOCUS ON THE CONTEXT FOR THE 1987 NSF BUDGET: THE IMPORTANCE OF BASIC RESEARCH TO THE NATION, THE STRATEGY UNDERLYING THE 1987 REQUEST, AND SOME HIGHLIGHTS.

BASIC RESEARCH IN THE UNITED STATES

THE FEDERAL GOVERNMENT WILL PROVIDE ABOUT $61 BILLION FOR SUPPORT OF R&D ACTIVITIES IN FY 1987. BASIC RESEARCH ACCOUNTS FOR ONLY $8.6 BILLION, OR 14%, OF THIS TOTAL. FEDERAL SUPPORT OF BASIC RESEARCH IS ESTIMATED TO INCREASE BY 8% IN FY 1987. SINCE A HIGHER PERCENTAGE INCREASE IS PROJECTED FOR SUPPORT OF DEVELOPMENT ACTIVITIES, THE SHARE OF RESEARCH DOLLARS THAT IS DEVOTED TO BASIC RESEARCH IS DROPPING.

CONTRARY TO OTHER COUNTRIES, IN THE U.S. ABOUT HALF OF ALL BASIC RESEARCH ACTIVITY TAKES PLACE IN COLLEGES AND UNIVERSITIES. WE HAVE CHOSEN TO LOCATE SO MUCH OF THE FEDERAL SUPPORT FOR BASIC RESEARCH AT OUR ACADEMIC INSTITUTIONS BECAUSE IN THIS WAY WE CAN ENSURE THE CONTINUED PRODUCTION OF TOP QUALITY SCIENTISTS AND ENGINEERS FOR ACADEMIA, INDUSTRY, AND GOVERNMENT. AS A CONSEQUENCE, HIGHER EDUCATION AND RESEARCH ARE INEXORABLY INTERTWINED; SUPPORTING ONE IS SUPPORTING THE OTHER.

THE PRESIDENT'S BUDGET REQUEST FOR NSF SHOWS AN INCREASE OF 15.6% ABOVE THE NEW OBLIGATIONAL AUTHORITY PROVIDED FOR FY 1986 AS ALTERED BY THE GRAMM-RUDMAN-HOLLINGS PROCESS. THIS SIGNALS THE EMPHASIS THIS ADMINISTRATION PLACES ON BASIC SCIENCE AND ENGINEERING AS A FORCE FOR PRESENT AND FUTURE COMPETITIVENESS, AS

A PREREQUISITE FOR THE PRODUCTS AND SERVICES THAT IMPROVE THE LIVES OF OUR CITIZENS, AND AS A BASE FOR BUILDING A STRONG NATIONAL DEFENSE.

THIS INCREASE OCCURS EVEN IN THE FACE OF LARGE FEDERAL DEFICITS AND EFFORTS TO REDUCE FEDERAL SPENDING BECAUSE INVESTMENT IN BASIC SCIENCE AND ENGINEERING IS ESSENTIAL TO IMPROVING OUR COMPETITIVENESS INTERNATIONALLY AND REDUCING OUR TRADE DEFICIT.

NSF HAS A UNIQUE ROLE IN THE FEDERAL SUPPORT OF SCIENCE AND ENGINEERING RESEARCH AND EDUCATION. OUR PROGRAMS PROVIDE SUPPORT FOR PROMISING IDEAS ACROSS ALL FIELDS OF SCIENCE AND ENGINEERING AND COMPLEMENT THE SUPPORT PROVIDED BY THE MORE MISSION-ORIENTED FEDERAL AGENCIES.

NSF ACCOUNTS FOR LESS THAN 3% OF THE FEDERAL SUPPORT FOR TOTAL RESEARCH AND DEVELOPMENT. HOWEVER, IT PROVIDES NEARLY 17% OF FEDERAL BASIC RESEARCH DOLLARS AND ABOUT 25% OF THE FEDERAL SUPPORT FOR BASIC RESEARCH AT COLLEGES AND UNIVERSITIES. THIS SUPPORT ALLOWS RESEARCHERS TO TACKLE PROBLEMS THAT REQUIRE LONGER-TERM INVESTMENTS NOT DIRECTLY DRIVEN BY THE NEED FOR SPECIFIC APPLICATIONS. IT IS FROM SUPPORT SUCH AS THIS THAT GENUINE BREAKTHROUGHS OCCUR, INNOVATION IS STIMULATED AND NOBEL PRIZES ARE EARNED.

PROBLEMS AND BUDGET STRATEGY

THE PROBLEMS THAT WE MUST ADDRESS ARE THE FOLLOWING:

1) OUR SUPPORT OF BASIC RESEARCH AND EDUCATION IN SCIENCE AND ENGINEERING NEEDS STRENGTHENING WHEN ONE CONSIDERS THE INCREASING RATE AT WHICH ADVANCES AND NEW DEVELOPMENTS ARE TAKING PLACE, AND THE AND INCREASING EMPHASIS AND SIGNIFICANT PROGRESS THAT OTHER NATIONS ARE MAKING IN THIS AREA.

2) WE ARE NOT ATTRACTING ENOUGH YOUNG PEOPLE TO SCIENCE AND ENGINEERING TO ASSURE AN ADEQUATE SUPPLY IN THE FUTURE.

3) OUR INVESTMENT IN THE INFRASTRUCTURE OF SCIENCE AND ENGINEERING--EQUIPMENT, INSTRUMENTATION, AND FACILITIES--MUST CONTINUE.

THE FOUNDATION'S BUDGET STRATEGY FOR FY 1987 ADDRESSES THESE ISSUES. THIS STRATEGY

O PROVIDES FOR CONTINUITY BY MAINTAINING BALANCED SUPPORT FOR RESEARCH OF PROVEN QUALITY ACROSS ALL DISCIPLINES.

- O ENSURES CHANGE BY INVESTING SIGNIFICANT RESOURCES IN A SELECTED NUMBER OF AREAS THAT OFFER PARTICULAR PROMISE FOR SCIENTIFIC AND ENGINEERING ADVANCES, AND

- O STRESSES FISCAL RESPONSIBILITY BY LEVERAGING FEDERAL RESOURCES WHEREVER POSSIBLE AND BY PHASING DOWN OR TERMINATING ACTIVITIES OF LOWER PRIORITY OR LESSER PROMISE.

STIMULATING COMPETITIVENESS AND INNOVATION

ECONOMIC COMPETITIVENESS IS AN IMPORTANT SUBJECT AT THIS TIME IN OUR NATION'S HISTORY. WE HAVE GONE FROM BEING A CREDITOR NATION TO ONE WITH GROWING TRADE DEFICITS. TRADE PROTECTION, HOWEVER, IS NOT THE ANSWER; DEVELOPING AND BEING FIRST IN THE USE OF NEW TECHNOLOGIES IS THE ANSWER. THEREFORE, SUPPORT FOR BASIC RESEARCH AND EDUCATION IN SCIENCE AND ENGINEERING IS ESSENTIAL. EVEN IN THE SHORT TERM, INVESTMENTS IN BASIC RESEARCH WILL HELP TO IMPROVE OUR COMPETITIVENESS. IN THE LONGER RUN, FAILURE TO PROVIDE SUBSTANTIAL SUPPORT FOR BASIC RESEARCH AND EDUCATION IS SURE TO HAVE GRAVE CONSEQUENCES.

THROUGH SUPPORT FOR SUCH PROGRAMS AS THE ENGINEERING RESEARCH CENTERS, INITIATED IN FY 1985, WE ARE PROVIDING OPPORTUNITIES FOR INDUSTRIAL AND ACADEMIC ENGINEERS AND SCIENTISTS TO WORK TOGETHER

IN AREAS OF INQUIRY WHICH REQUIRE A STRONGER FUNDAMENTAL RESEARCH BASE FOR FUTURE ADVANCES. THESE CENTERS ALSO PROVIDE EXPERIENCES FOR UNDERGRADUATE AND GRADUATE STUDENTS WHICH CAN BETTER PREPARE THEM FOR CAREERS IN INDUSTRIAL RESEARCH. SIX CENTERS HAVE BEEN ESTABLISHED. WE WILL VERY SHORTLY ANNOUNCE AWARDS FOR FOUR OR FIVE MORE, AND THE FY 1987 BUDGET REQUEST INCLUDES SUPPORT FOR AN ADDITIONAL FOUR CENTERS.

THERE IS GREAT POTENTIAL FOR LONG-TERM ECONOMIC PAYOFF IN OTHER RESEARCH AREAS, INCLUDING MATERIALS, CHEMISTRY, COMPUTER SCIENCE AND BIOTECHNOLOGY. ALL OF THESE AREAS RECEIVE ENHANCED SUPPORT IN FY 1987, BOTH IN ONGOING BASE PROGRAMS AND THROUGH THE SPECIAL EMPHASIS AREAS OF COMPUTATIONAL SCIENCE AND ENGINEERING, BIOTECHNOLOGY, AND GLOBAL GEOSCIENCES.

OUR EFFORTS IN SUPPORT OF RESEARCH CONDUCTED BY SMALL BUSINESSES AND OF JOINT INDUSTRY-UNIVERSITY RESEARCH VENTURES ARE DIRECTLY AIMED AT ENCOURAGING INNOVATION AND BUILDING STRONGER LINKS BETWEEN BASIC RESEARCH ACTIVITIES OF TODAY AND ECONOMIC ADVANCES IN THE FUTURE.

WE CANNOT TAKE LEADERSHIP IN SCIENCE AND ENGINEERING RESEARCH AND TECHNOLOGY FOR GRANTED. OUR TRADING PARTNERS ABROAD ARE INCREASING VERY SIGNIFICANTLY THEIR COMMITMENTS TO RESEARCH AND THEIR EFFORTS ARE PAYING OFF IN INCREASED WORLD MARKET SHARES. WE MUST BE WILLING TO INVEST ADEQUATELY TO NARROW THE GAP BETWEEN

RESEARCH RESULTS AND THE MARKETPLACE. THE EFFORTS DESCRIBED ABOVE ARE ILLUSTRATIVE OF THE NSF APPROACH TO CONTRIBUTING TO THE MAINTENANCE OF A PREEMINENT POSITION FOR THE U.S. IN ECONOMIC COMPETITION.

DEVELOPING SCIENCE AND ENGINEERING PERSONNEL

THE HUMAN RESOURCE POOL THAT WILL PROVIDE THE SCIENTISTS AND ENGINEERS OF THE FUTURE IS CRITICALLY IMPORTANT. FOR THE YOUNG MEN AND WOMEN ALREADY IN THE CAREER PIPELINE, NSF PROVIDES SUPPORT FOR THE INITIATION OF INDIVIDUAL RESEARCH PROGRAMS AT COLLEGES AND UNIVERSITIES, FOR POSTDOCTORAL OPPORTUNITIES, AND FOR GRADUATE RESEARCH ASSISTANTSHIPS AND FELLOWSHIPS. AT THE UNDERGRADUATE LEVEL, AND PARTICULARLY THE PRECOLLEGE YEARS, WHERE CAREER DECISIONS ARE NOT YET FIRM, THE FOUNDATION DIRECTS SPECIAL EFFORTS TOWARD MAKING SCIENTIFIC AND TECHNICAL CAREERS ATTRACTIVE AND ATTAINABLE. IN ALL OF THESE EFFORTS, INCREASING THE PARTICIPATION OF WOMEN, MINORITIES, AND PHYSICALLY DISABLED PERSONS IN SCIENTIFIC AND ENGINEERING ACTIVITIES IS AN IMPORTANT FOUNDATION GOAL.

SUPPORT FOR PRECOLLEGE SCIENCE AND MATHEMATICS ACTIVITIES IS STABILIZED AT THE FY 1986 LEVEL. THE FY 1987 PROGRAM BUILDS ON, AND CONTINUES, ACTIVITIES BEGUN EARLIER. THESE INCLUDE MATERIALS DEVELOPMENT, INFORMAL EDUCATION, TEACHER PREPARATION AND

ENHANCEMENT, AND STUDIES AND ASSESSMENTS. THESE ACTIVITIES ARE ALL CONSISTENT WITH THE FUNCTIONAL OBJECTIVES AS DESCRIBED IN THE REAUTHORIZATION OF THE EDUCATION FOR ECONOMIC SECURITY ACT, P.L. 99-159. ALL OF THE SCIENCE AND MATHEMATICS FIELDS TAUGHT AT THE K-12 LEVELS ARE COVERED. IN THE TEACHER ENHANCEMENT AREA, ABOUT 10,000 TEACHERS PER YEAR ARE PARTICIPATING IN PROJECTS. THE GOAL OF THESE ACTIVITIES IS TO IMPROVE THE QUALITY OF PRECOLLEGE INSTRUCTION IN SCIENCE AND MATHEMATICS, PROVIDE MEANINGFUL OUT-OF-SCHOOL EXPERIENCES FOR YOUNG PEOPLE, AND STIMULATE YOUNG MEN AND WOMEN TO CONSIDER CAREERS IN SCIENCE AND ENGINEERING FIELDS.

THE MANAGEMENT STUDY MANDATED IN THE FY 1985 APPROPRIATION FOR NSF HAS JUST BEEN FUNDED. THE STUDY WILL BE COMPLETED IN 18 MONTHS, WITH SEVERAL INTERIM REPORTS REQUIRED. AS INFORMATION BECOMES AVAILABLE IT WILL BE USED IN UPDATING AND REFORMULATING THE SCIENCE AND ENGINEERING EDUCATION LONG RANGE PLAN.

IMPROVING THE PHYSICAL INFRASTRUCTURE OF SCIENCE AND ENGINEERING

ADVANCES IN SCIENCE AND ENGINEERING ARE INCREASINGLY DEPENDENT ON THE EQUIPMENT AVAILABLE TO RESEARCHERS. INSTRUMENTATION AND FACILITIES MUST BE OF THE HIGHEST QUALITY POSSIBLE IF WE ARE TO MAINTAIN OUR SCIENCE AND TECHNOLOGY BASE AND REALIZE FUTURE ADVANCES.

IN RECENT YEARS, WE HAVE REDUCED OR RESCHEDULED SEVERAL MAJOR CAPITAL INVESTMENTS IN RESEARCH FACILITIES. THIS HAS BEEN A NECESSARY AND APPROPRIATE RESPONSE TO FINANCIAL CONSTRAINTS. HOWEVER, IT DOES NOT CONSTITUTE AN ACCEPTABLE LONG-TERM POLICY FOR RESEARCH SUPPORT. THIS BUDGET INCLUDES SUPPORT FOR ON-GOING CAPITAL IMPROVEMENTS; NO NEW STARTS ARE INCLUDED.

EACH FACILITY IMPROVEMENT HAS BEEN CAREFULLY EXAMINED TO ENSURE THAT THE SUPPORT WE ARE REQUESTING BALANCES THE NEED FOR FISCAL RESTRAINT AND THE SCIENTIFIC NEED FOR THE FACILITY. FOR EXAMPLE, THE CORNELL ELECTRON STORAGE RING UPGRADE WILL CONTINUE (ALTHOUGH ITS COMPLETION WILL BE DELAYED ONE YEAR), WHILE CONSTRUCTION OF THE MICHIGAN STATE UNIVERSITY CYCLOTRON AND THE INDIANA UNIVERSITY COOLER RING WILL BE COMPLETED. SUPPORT FOR THE CONSTRUCTION OF THE VERY LONG BASELINE ARRAY WILL BE MAINTAINED AT ESSENTIALLY THE FY 1986 LEVEL.

MODERN RESEARCH REQUIRES STATE-OF-THE-ART INSTRUMENTATION AND EQUIPMENT. ACCORDINGLY, THE FY 1987 BUDGET REQUEST INCLUDES FUNDS FOR INCREASED INVESTMENT IN DISCIPLINE-SPECIFIC RESEARCH INSTRUMENTATION PROGRAMS AND FOR AN EXPANSION OF THE COLLEGE SCIENCE INSTRUMENTATION PROGRAM. INCREASES FOR INSTRUMENTATION OCCUR THROUGHOUT THE DISCIPLINES SUPPORTED BY THE FOUNDATION, WITH SPECIAL ATTENTION FOCUSED ON THE BIOLOGICAL SCIENCES THIS YEAR.

LEVERAGING FEDERAL DOLLARS

NSF CONTINUES IN FY 1987, AS IN PREVIOUS YEARS, TO LEVERAGE FEDERAL DOLLARS BY ENCOURAGING AND REQUIRING THE PARTICIPATION OF PRIVATE SECTOR ORGANIZATIONS, ACADEMIC INSTITUTIONS, AND STATE AND LOCAL GOVERNMENTS AS PARTNERS IN FUNDING RESEARCH AND EDUCATION. SOME PROGRAMS REQUIRE CONTRIBUTIONS FROM THESE AND OTHER SOURCES.

EXAMPLES OF THE SUCCESSES WE HAVE ACHIEVED IN ATTRACTING OUTSIDE FUNDING TO COMPLEMENT AND EXTEND THE SUPPORT BY NSF:

- THE SIX ENGINEERING RESEARCH CENTERS ESTABLISHED LAST YEAR HAVE GENERATED APPROXIMATELY $13 MILLION IN INDUSTRIAL SUPPORT;

- THE NATIONAL ADVANCED SCIENTIFIC COMPUTING CENTERS WHICH WERE ALSO INITIATED LAST YEAR HAVE RAISED A 40 CENT MATCH FOR EVERY DOLLAR THE FEDERAL GOVERNMENT SPENDS;

- THE $5.5 MILLION PROVIDED FOR THE FY 1985 COLLEGE SCIENCE INSTRUMENTATION PROGRAM AWARDS WILL BE MATCHED BY AT LEAST AN EQUAL AMOUNT; AND

- The FY 1984 class of Presidential Young Investigators has succeeded in obtaining nearly $11 million in matching funds.

- So far during FY 1986, $1.9 million NSF investment in precollege instructional development has been matched by nearly $9 million from other sources.

THE NSF BUDGET REQUEST FOR FY 1987

The strategy we have adopted is embodied in the Foundation's FY 1987 Budget Request, which totals $1,685.7 million or 13.2% above the approved FY 1986 Post Gramm-Rudman-Hollings Current Plan of $1,489.8 million. This Current Plan is composed of $1458.3 million in New Obligational Authority (NOA) and $31.5 million deferred from FY 1985 for use in FY 1986 for Science and Engineering Education. The FY 1987 Request is therefore 15.6% above the FY 1986 NOA. It includes:

- $1,479 million for Research and Related Activities, an increase of 14.3%.

- $117 million for the U.S. Antarctic Program (USAP), up 6.4%. (A budget base transfer of $14.4 million was made to the U.S. Coast Guard to cover basic icebreaker services. Those funds include part of a $3.0 million increase in Coast Guard charges.)

- $89 million, or a 5.1% increase, for Science and Engineering Education. (The carryover of $31.5 million from FY 1985 into FY 1986 has been made part of the base for Science and Engineering Education.)

- $0.7 million in Special Foreign Currency funds.

This Budget Request, if approved by Congress:

- Will maintain balanced support for research of proven quality across all disciplines.

- Will allow significant increases for a small number of multidisciplinary special emphasis areas where additional funding can have a multiplier effect by establishing new institutional arrangements and capabilities for encouraging the collaboration that accelerate scientific productivity.

- WILL PROVIDE SUPPORT FOR FACILITIES WHICH ARE AN INTEGRAL PART OF RESEARCH ACTIVITIES IN FIELDS SUCH AS PHYSICS, MATERIALS, ADVANCED SCIENTIFIC COMPUTING, ASTRONOMY, AND THE GEOSCIENCES.

- WILL STABILIZE FUNDING FOR THE SCIENCE AND ENGINEERING EDUCATION ACTIVITY, MAINTAINING THE FY 1986 LEVEL FOR GRADUATE AND PRECOLLEGE PROGRAMS AND AN INCREASE FOR THE COLLEGE SCIENCE INSTRUMENTATION PROGRAM.

SPECIAL EMPHASES FOR FY 1987

FOUR AREAS HAVE BEEN IDENTIFIED FOR SPECIAL EMPHASIS IN FY 1987: THREE SCIENTIFIC RESEARCH AREAS AND ONE INFRASTRUCTURE AREA. THE THREE SCIENTIFIC AREAS ARE BIOTECHNOLOGY, COMPUTATIONAL SCIENCE AND ENGINEERING AND GLOBAL GEOSCIENCES. EACH IS MULTIDISCIPLINARY IN NATURE, AND THIS DEMANDS COLLABORATIVE EFFORTS AND SOPHISTICATED EQUIPMENT. THEY ARE AREAS WHERE ADDITIONAL FUNDING CAN HAVE A LARGE MULTIPLIER EFFECT BY ESTABLISHING NEW INSTITUTIONAL ARRANGEMENTS FOR ENCOURAGING THE COLLABORATION THAT WILL ACCELERATE AND INTENSIFY SCIENTIFIC PRODUCTIVITY. THE FOURTH EMPHASIS ADDRESSES THE NEED TO BUILD A STRONG, DIVERSE BASE, BOTH OF PEOPLE AND INSTITUTIONS, FOR THE PERFORMANCE OF RESEARCH IN THE FUTURE.

BIOTECHNOLOGY

THE BIOTECHNOLOGY INDUSTRY IN THE U.S. IS A SUCCESSFUL AND GROWING ENTERPRISE. THE U.S. IS CURRENTLY THE WORLD LEADER IN MANY ASPECTS OF BIOTECHNOLOGY. THAT LEADERSHIP CANNOT BE MAINTAINED WITHOUT CONTINUED EFFORT.

THE SUCCESS OF COMMERCIAL BIOTECHNOLOGY RELIES HEAVILY ON THE FUNDAMENTAL RESEARCH BASE AND IS INCREASINGLY MULTIDISCIPLINARY IN NATURE. FUTURE ADVANCES WILL REQUIRE:

O ENHANCED DEVELOPMENT OF THE KNOWLEDGE BASE, ESPECIALLY IN AREAS WITH GAPS THAT LIMIT PROGRESS, AND

O SCIENTISTS AND ENGINEERS WITH SOLID DISCIPLINARY TRAINING AND SKILLS, WORKING IN RESEARCH ENVIRONMENTS THAT ENCOURAGE MULTIDISCIPLINARY EFFORTS.

THE FOUNDATION HAS INCREASED SUPPORT FOR FUNDAMENTAL BIOTECHNOLOGY-RELATED RESEARCH OVER THE PAST SEVERAL YEARS. OUR FIRST EFFORTS WERE MAINLY AIMED AT INCREASING SUPPORT FOR THE PLANT SCIENCES, INCLUDING THE ESTABLISHMENT OF A PLANT SCIENCES POSTDOCTORAL FELLOWSHIP PROGRAM. IN FY 1985, ATTENTION WAS DIRECTED TO THE INITIATION OF COLLABORATIVE EFFORTS BETWEEN

CHEMISTS AND BIOLOGISTS TO GAIN A DEEPER UNDERSTANDING OF LIFE PROCESSES. IN THE ENGINEERING RESEARCH CENTER PROGRAM AN AWARD WAS MADE TO THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY TO ESTABLISH A CENTER FOR BIOTECHNOLOGY PROCESS ENGINEERING.

FOR FY 1987, AN INCREASE OF $20 MILLION IS REQUESTED OVER THE FY 1986 LEVEL OF $86.5 MILLION. THE INCREMENTAL FUNDS WILL BE USED FOR MULTIDISCIPLINARY RESEARCH CENTERS, MULTI-USER EQUIPMENT, AND CROSS-DISCIPLINARY RESEARCH AND TRAINING PROGRAMS.

COMPUTATIONAL SCIENCE AND ENGINEERING

ADVANCED RESEARCH IN MANY AREAS OF SCIENCE AND ENGINERING INCREASINGLY RELIES ON COMPUTATIONAL METHODS TO CALCULATE, SIMULATE, AND MODEL COMPLEX RELATIONSHIPS, NEW CONCEPTS AND IDEAS. THIS APPROACH IS COMPLEMENTARY TO THE TRADITIONAL EXPERIMENTAL AND THEORETICAL APPROACHES AND PROVIDES AN IMPORTANT NEW TOOL THAT ENHANCES AND ACCELERATES SCIENTIFIC PROGRESS.

UNTIL RECENTLY, THE U.S. ACADEMIC RESEARCH COMMUNITY HAD LIMITED OPPORTUNITY TO EMPLOY ADVANCED COMPUTATIONAL METHODS BECAUSE OF LACK OF ACCESS TO THE MOST ADVANCED COMPUTERS. NSF BEGAN TO ADDRESS THIS NEED IN FY 1985 WITH THE ESTABLISHMENT OF NATIONAL SUPERCOMPUTING CENTERS AND THE PROVISION OF INCREASED ACCESS TO ADVANCED COMPUTERS TO SCIENTISTS AND ENGINEERS FROM MANY

DISCIPLINES. THE EFFORT HAS BEEN LARGELY SINGLE-INVESTIGATOR CENTERED.

THE FY 1987 EMPHASIS ENCOURAGES COLLABORATIVE, MULTIDISCIPLINARY APPROACHES TO COMPLEX PROBLEMS,THUS CAPITALIZING ON THE DIFFERENT PERSPECTIVES OF MATHEMATICIANS, COMPUTER SCIENTISTS AND SCIENTISTS AND ENGINEERS FROM OTHER DISCIPLINES.

IN FY 1986, APPROXIMATELY $57 MILLION WILL BE ALLOCATED TO COMPUTATIONAL SCIENCE AND ENGINEERING ACTIVITIES. IN FY 1987, AN ADDITIONAL $27 MILLION IS REQUESTED TO ESTABLISH NEW MULTIDISCIPLINARY TEAMS, ENHANCE EXISTING CENTERS AND GROUPS, AND PROVIDE EQUIPMENT AND TRAINING OPPORTUNITIES.

GLOBAL GEOSCIENCES

THE FY 1987 BUDGET REQUEST SEEKS AN INCREASE OF $18 MILLION, OVER AN ESTIMATED FY 1986 BASE OF $17 MILLION, FOR INCREASED EMPHASIS ON GLOBAL GEOSCIENCES THROUGH A SERIES OF INTERRELATED RESEARCH EFFORTS TREATING THE EARTH AS AN INTEGRATED SYSTEM OF PHYSICAL, CHEMICAL, AND BIOLOGICAL PROCESSES. DISCIPLINES FROM THE ATMOSPHERIC, ASTRONOMICAL, EARTH AND OCEAN SCIENCES ACTIVITY AND THE BIOTIC SYSTEMS AND RESOURCES SUBACTIVITY OF THE BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES ACTIVITY WILL PARTICIPATE IN THE EMPHASIS. THERE WILL ALSO BE SIGNIFICANT PARTICIPATION IN THESE ACTIVITIES BY OTHER AGENCIES, INCLUDING NASA, NOAA, AND THE USGS.

STUDIES OF GLOBAL OCEAN AND ATMOSPHERIC CIRCULATION, CHEMISTRY OF THE TROPOSPHERE, ECOSYSTEM DYNAMICS, BIOLOGICAL DIVERSITY AND PRODUCTIVITY, AND SOLID EARTH PROPERTIES WILL BE SUPPORTED. THE RESULTS WILL PROVIDE COHESIVE APPROACHES TO STUDIES OF THESE AREAS, CREATE NEW DATA SETS, AND DIRECTLY INVIGORATE THE CONSTITUENT BASIC SCIENCE DISCIPLINES.

THE ACTIVITIES WHICH WILL BE FUNDED THROUGH THIS EMPHASIS ARE PART OF MAJOR INTERNATIONAL EFFORTS TO UNDERSTAND NATURAL PHENOMENA WHICH CROSS REGIONAL AND NATIONAL BOUNDARIES. INCREASED UNDERSTANDING OF THESE PROCESSES CAN LEAD TO BETTER PREDICTIVE MODELS FOR NATURAL EVENTS SUCH AS THE EL NINO OCEANIC/ATMOSPHERIC PHENOMENON, EARTHQUAKES AND VOLCANIC ERUPTIONS, AND THE CONSEQUENCES OF HUMAN ACTIVITY , SUCH AS ACID RAIN AND DEFORESTATION.

BROADENING PARTICIPATION IN SCIENCE AND ENGINEERING

THE FOUNDATION HAS A DUAL ROLE IN THE SUPPORT OF THE PEOPLE AND INSTITUTIONS THAT WILL BE THE PERFORMERS OF SCIENCE AND ENGINEERING RESEARCH IN THE FUTURE:

- O TO ASSURE THE EXCELLENCE OF OUR RESEARCH, TIMELY DISCOVERIES, AND THE QUALITY OF EDUCATION TO KEEP THE U.S. COMPETITIVE IN TOMORROW'S WORLD; AND

- O TO ENSURE THAT THE BROADEST POSSIBLE RANGE OF TALENT, BOTH OF PEOPLE AND INSTITUTIONS, IS ABLE TO PARTICIPATE IN SCIENTIFIC AND ENGINEERING RESEARCH.

IN CARRYING OUT THESE RESPONSIBILITIES, ISSUES OF GEOGRAPHIC, INSTITUTIONAL, AND PERSONNEL DISTRIBUTION ARE RECOGNIZED AS LEGITIMATE CONSIDERATIONS IN THE DEVELOPMENT AND MAINTENANCE OF OUR SCIENCE AND ENGINEERING BASE.

THE FOUNDATION HAS EMPLOYED TARGETED PROGRAMS AS WELL AS EFFORTS INTEGRATED INTO ALL OF THE AGENCY'S PROGRAMS IN ITS EFFORTS TO BROADEN PARTICIPATION IN SCIENCE AND ENGINEERING. FOR FY 1987 THIS BASIC STRATEGY CONTINUES AND IS ENHANCED.

PROGRAMS AIMED AT INCREASING THE PARTICIPATION OF WOMEN AND MINORITIES ARE OF BOTH TYPES: TARGETED AND MAINSTREAMED. FOR EXAMPLE, THE VISITING PROFESSORSHIPS FOR WOMEN PROGRAM IS LOCATED IN THE STIA ACTIVITY, AS IS THE RESEARCH IMPROVEMENT IN MINORITY INSTITUTIONS PROGRAM. BOTH OF THESE PROGRAMS ARE CENTRALLY MANAGED AND BUDGETED. BOTH ARE MAINTAINED AT THE FY 1986 LEVEL. ON THE OTHER HAND, RESEARCH INITIATION PROGRAMS FOR MINORITIES AND WOMEN HAVE BEEN MAINSTREAMED: DISCIPLINARY RESEARCH PROGRAMS ARE

RESPONSIBLE FOR BUDGETING AND MANAGING THESE EFFORTS WHILE STIA PROVIDES FOUNDATION-WIDE COORDINATION AND MONITORING. THE TARGETS FOR BOTH OF THESE RESEARCH INITIATION EFFORTS ARE INCREASED FOR FY 1987.

IN FY 1987, A NEW PROGRAM, MINORITY RESEARCH CENTERS OF EXCELLENCE, IS INCLUDED IN THE BUDGET REQUEST FOR THE SCIENTIFIC, TECHNOLOGICAL AND INTERNATIONAL AFFAIRS ACTIVITY. THROUGH THIS PROGRAM, A SMALL NUMBER OF MINORITY INSTITUTIONS THAT HAVE STRONG SCIENCE OR ENGINEERING PROGRAMS WILL BE ASSISTED IN BECOMING CENTERS OF EXCELLENCE. THESE CENTERS WILL CONDUCT RESEARCH, PROVIDE GRADUATE TRAINING, WORK WITH ASSOCIATED UNDERGRADUATE INSTITUTIONS, ESTABLISH STRONG TIES WITH NEARBY PRECOLLEGE TEACHERS AND SCHOOLS, AND SERVE AS COMMUNITY RESOURCES FOR STIMULATING MINORITY YOUNG PEOPLE TO CONSIDER CAREERS IN SCIENCE AND ENGINEERING.

FOR THE LAST SEVERAL YEARS, NSF HAS INCREASED ITS SUPPORT OF UNDERGRADUATE RESEARCH AND EDUCATION, LARGELY THROUGH ITS FOCUS ON RESEARCH IN PREDOMINANTLY UNDERGRADUATE INSTITUTIONS. IN FY 1987 SIGNIFICANT ENHANCEMENT AND EXTENSION OF THIS EFFORT IS PROPOSED. UNDERGRADUATE FACULTY AND STUDENT RESEARCH OPPORTUNITIES WILL BE INCREASED, REGARDLESS OF THE PARENT INSTITUTION SIZE AND ORIENTATION. SUPPORT FOR UNDERGRADUATE INSTRUCTIONAL INSTRUMENTATION WILL BE INCREASED THROUGH THE COLLEGE SCIENCE

INSTRUMENTATION PROGRAM. THE FOCUS ON SUPPORT FOR RESEARCH AT PREDOMINANTLY UNDERGRADUATE INSTITUTIONS WILL CONTINUE IN ALL THE RESEARCH PROGRAMS OF THE FOUNDATION.

FINALLY, THE EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH (EPSCoR) WILL BE CONTINUED AND ENHANCED. THE PROGRAM PROVIDES MODEST FUNDS FOR PLANNING AND IMPLEMENTATION TO BUILD SCIENCE AND ENGINEERING CAPACITY IN STATES THAT HAVE NOT RECEIVED LARGE NUMBERS OF NSF AWARDS. UP TO EIGHT AWARDS WILL BE MADE IN FY 1987.

OTHER NSF EFFORTS TO BUILD THE SCIENTIFIC AND ENGINEERING PERSONNEL POOL FOR THE FUTURE WILL CONTINUE. THESE INCLUDE THE GRADUATE FELLOWSHIPS PROGRAM, GRADUATE RESEARCH ASSISTANTSHIPS, POSTDOCTORAL RESEARCH ASSSOCIATES, AND PRESIDENTIAL YOUNG INVESTIGATOR AWARDS.

THROUGH THESE COMPLEMENTARY APPROACHES, NSF WILL CONTRIBUTE TO BUILDING A SCIENTIFIC AND ENGINEERING WORKFORCE THAT IS CHARACTERIZED BOTH BY EXCELLENCE AND DIVERSITY.

CONCLUSION

MR. CHAIRMAN, I HOPE THAT THIS OVERVIEW PROVIDES A SENSE OF THE PROBLEMS WE ARE FACING AND THE STRATEGY WE HAVE CHOSEN TO ADDRESS THEM. WE ARE ENCOURAGED BY THE BUDGET REQUEST LEVEL THAT THE

PRESIDENT HAS SENT FORWARD. WE, OF COURSE, BELIEVE THAT SCIENCE AND ENGINEERING ARE KEYS TO THE FUTURE WELL-BEING OF OUR COUNTRY. I HOPE THAT THE FINAL ACTION TAKEN BY THE CONGRESS ON THE NATIONAL SCIENCE FOUNDATION'S FY 1987 BUDGET REQUEST WILL HELP US ULTIMATELY TO PROVIDE THOSE KEYS FOR THE NATION, AND WE ASK FOR THIS COMMITTEE'S SUPPORT TOWARD THAT END.

STATEMENT OF

DR. ROLAND W. SCHMITT

CHAIRMAN, NATIONAL SCIENCE BOARD

SUBMITTED TO THE COMMITTEE ON LABOR AND HUMAN RESOURCES

U.S. SENATE

ON THE FISCAL YEAR 1987

NATIONAL SCIENCE FOUNDATION BUDGET REQUEST

MARCH 26, 1986

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

MY PRIMARY MESSAGE THIS MORNING IS THAT ACADEMIC RESEARCH AND EDUCATION IS CENTRAL TO THE NATION'S ECONOMIC AND DEFENSE STRENGTH. THE INTERNATIONAL COMPETITION OF THE PAST DECADE HAS BEEN WAGED, AND WILL CONTINUE TO BE WAGED, ON TECHNOLOGICAL GROUNDS. OUR INDUSTRIES THAT HAVE BEEN SURPASSED HAVE BEEN SURPASSED BY MORE ADVANCED TECHNOLOGY. THOSE RUNNING NECK-AND-NECK WITH THE COMPETITION, SUCH AS THE SEMICONDUCTOR INDUSTRY, WILL ONLYS STAY THAT WAY IF THEY KEEP PACE WITH FOREIGN TECHNOLOGY. AND THOSE THAT ARE STILL AHEAD, SUCH AS THE COMPUTER, AIRCRAFT ENGINE, AND PLASTICS INDUSTRY, ARE AHEAD BECAUSE THEIR TECHNOLOGY IS AHEAD. IT IS TRUE THAT OTHER FACTORS PLAY HEAVILY IN THE COMPETITIVE EQUATION. AND IT IS TRUE THAT WE MUST HAVE A LEVEL PLAYING FIELD. BUT ON A LEVEL PLAY FIELD, TECHNOLOGY IS THE DISTINGUISHING FACTOR. AND WHEN THE FIELD IS NOT LEVEL, TECHNOLOGY IS THE OFFSETTING FACTOR. IF WE ARE TO WIN IN INTERNATIONAL COMPETITION, IT WON'T BE ON THE BASIS OF CHEAPER LABOR, OR CHEAPER CAPITAL, OR A FAVORABLE EXCHANGE RATE. IT WILL BE ON THE BASIS OF TECHNOLOGY.

FROM AN INDUSTRIAL PERSPECTIVE, BY ALL MEANS THE FEDERAL GOVERNMENT MUST STRIVE TO LEVEL THE PLAYING FIELD. BUT, JUST AS IMPORTANTLY, IT MUST MAKE THE INVESTMENTS IN THE BASIC RESOURCES NEEDED BY INDUSTRY AND DEFENSE TO WIN IN INTERNATIONAL COMPETITION. MANY OF THE REQUIREMENTS FOR SUCCESS LIE WITH

ACTIONS THAT ONLY INDUSTRY CAN TAKE--STREAMLINING OPERATIONS. FORESIGHT IN INVESTMENT, COMMITMENT TO R&D, CREATIVITY IN MARKETING, AND PERHAPS ABOVE ALL ELSE, THE ABILITY TO MOVE QUICKLY. BUT INDUSTRY ALSO NEEDS TWO THINGS THAT IT CAN'T PRODUCE ON ITS OWN:

- SCIENTIFIC AND ENGINEERING TALENT
- FUNDAMENTAL SCIENTIFIC AND ENGINEERING KNOWLEDGE

THERE ARE THE RAW MATERIALS. ONLY ACADEMIC SCIENCE AND ENGINEERING--THE SCIENCE AND ENGINEERING BASE--CAN PRODUCE THEM.

EXAMPLES OF THE IMPORTANCE OF THE ACADEMIC BASE TO INDUSTRY ABOUND. ONE NEED LOOK NO FURTHER THAN TO THE FIELD OF ELECTRONICS, TO SUCH UNIVERSITY-SPAWNED DEVELOPMENTS AS SILICON COMPILERS AND REDUCED INSTRUCTION SET COMPUTERS. MOST OF CHEMISTRY, MATERIALS SCIENCE, SOLID STATE PHYSICS, BIOCHEMISTRY AND COMPUTER SCIENCE ARE SO INTEGRAL TO INDUSTRIAL TECHNOLOGY THAT THE DISTINCTIONS BETWEEN BASIC AND APPLIED RESEARCH ARE BECOMING EVEN MORE BLURRED. AND IN MANY AREAS OF ENGINEERING RESEARCH, FUNDAMENTAL RESEARCH ISSUES--FOR EXAMPLE, IN GEOMETRIC MODELING AND ANALYSES, IN ARTIFICIAL VISION, IN MOTION CONTROL, IN EXPERT SYSTEMS--ARE ESSENTIAL TO THE DESIGN OF NEW PRODUCTS AND PROCESSES.

YET, DESPITE THE IMPORTANCE OF THE BASE TO COMPETITIVENESS, THE STRENGTH OF THE U.S. ACADEMIC RESEARCH AND EDUCATION BASE SHOWS SIGNS OF WEAR. THE SYMPTOMS ABOUND:

- IN OUTDATED RESEARCH EQUIPMENT
- IN OBSOLETE AND INADEQUATE RESEARCH FACILITIES
- IN DECLINES OVER THE PAST TWO DECADES IN THE NUMBER OF GRADUATES RECEIVING PH.D.'S IN KEY FIELDS OF SCIENCE AND ENGINEERING, AND IN A CONCOMITANT INCREASE IN THE NUMBER OF FOREIGN NATIONAL PH.D.'S.
- AND IN THE DECLINE OF SCIENCE AND ENGINEERING EDUCATION ACROSS THE BOARD.

THE AGENDA, NOT MERELY FOR THE FEDERAL GOVERNMENT, BUT FOR ALL OF US--FOR INDUSTRY, FOR UNIVERSITIES, FOR THE STATES--IS LARGE AND GROWING. BUT IT MUST BE MET, UNLESS WE ARE WILLING TO CEDE OUR TECHNOLOGICAL LEADERSHIP TO OTHERS.

THAT BRINGS ME TO THE NATIONAL SCIENCE FOUNDATION AND ITS BUDGET FOR FY 1987. THE NSF ACCOUNTS FOR A VERY SMALL PORTION OF THE FEDERAL R&D BUDGET, LESS THAN 3%. BUT IN THE CONTEXT OF INTERNATIONAL COMPETITIVENESS, IT IS A CRITICAL, HIGH LEVERAGE COMPONENT OF THE FEDERAL BUDGET. IT IS THE ONE COMPONENT OF THAT BUDGET DIRECTLY AND ENTIRELY CONCERNED NOT WITH THE PURSUIT OF GOVERNMENT MISSIONS, BUT WITH THE STRENGTH OF ACADEMIC RESEARCH AND EDUCATION. IT MAY BE THE SMALLEST COMPONENT OF THE FEDERAL R&D BUDGET, BUT FROM THE PERSPECTIVE OF COMPETITIVENESS, IT IS THE MOST IMPORTANT. THIS IS THE CONTEXT IN WHICH THE FY 1987 BUDGET PROPOSAL SHOULD BE JUDGED.

I WOULD LIKE TO THANK YOU, MR. CHAIRMAN, AND ALL THE MEMBER OF THE COMMITTEE FOR THE EFFORTS OVER THE PAST SEVERAL YEARS TO SECURE A PROPER AUTHORIZATION FOR THE FOUNDATION. THE CHANGE MADE IN THIS YEAR'S BILL TO ELIMINATE THE RESTRICTIONS ON THE BOARD'S AUTHORITY TO DELEGATE TO THE DIRECTOR AUTHORITY TO ACT ON AWARDS HAS HAD A SIGNIFICANT AND BENEFICIAL EFFECT ON BOARD OPERATIONS. SINCE MEMBERSHIP ON THE BOARD IS A PART-TIME OCCUPATION, WE HAVE BEEN ANXIOUS TO FOCUS OUR ATTENTION ON THE POINTS OF GREATEST LEVERAGE-RECEIVING PROGRAMS AND PLANS AT AN EARLY STAGE OF THEIR FORMULATION AND THEREBY TO HELP GUIDE AND SHAPE THE PRIORITIES OF THE FOUNDATION.

WE HAVE TAKEN ADVANTAGE OF THE FLEXIBILITY OFFERED BY THE NEW AUTHORIZATION ACT TO RAISE THE MINIMUM AWARD LEVEL THAT REQUIRES BOARD REVIEW TO A TOTAL OF $6 MILLION, WHICH ROUGHLY ACCOUNTS FOR INFLATION SINCE THE LEVEL WAS LAST SET IN 1986. WE HAVE ALSO DELEGATED AUTHORITY FOR REVIEW OF CERTAIN LARGE BUT ROUTINELY RECURRING AWARDS TO THE DIRECTOR. THESE CHANGES HAVE ENABLED US TO BALANCE OUR EFFORTS AT PROJECT REVIEW WITH CONSIDERABLY MORE ATTENTION TO THE BROADER, LONG-TERM STRATEGIC ISSUES CONFRONTING THE FOUNDATION.

WE GREATLY APPRECIATE THE TRUST AND CONFIDENCE IN THE BOARD AND THE FOUNDATION THAT YOU DEMONSTRATED BY MAKING THIS CHANGE IN THE AUTHORIZATION ACT. WE ALSO APPRECIATE THE ADDITION OF

"ENGINEERING" TO THE NSF ACT. IT ACKNOWLEDGES AND REINFORCES OUR DETERMINATION TO ENSURE THAT NSF BE ATTENTIVE TO THE RESEARCH AND EDUCATION NEEDS OF ENGINEERING AS WELL AS SCIENCE.

TURNING BACK TO THE BUDGET, THE PRESIDENT IS PROPOSING AN 8% INCREASE FOR THE FOUNDATION AND IS ALSO PROPOSING REAL GROWTH IN GOVERNMENT-WIDE SUPPORT FOR BASIC RESEARCH. IN THE PHYSICAL SCIENCES AND ENGINEERING, THE INCREASES ARE EVEN LARGER. IN LIGHT OF THE SEVERE BUDGET CONSTRAINTS THAT WE ARE OPERATING UNDER, THIS INCREASE REFLECTS THE ADMINISTRATION'S CONTINUED COMMITMENT TO THE STRENGTH OF THE BASE. IN THE CONTEXT OF THE BUDGET CONSTRAINTS, THE INCREASE IS SUBSTANTIAL. BUT IN THE CONTEXT OF THE IMPORTANCE OF THE SCIENCE AND ENGINEERING BASE TO THE NATION'S COMPETITIVENESS, AND IN THE CONTEXT OF THE GROWING SIGNS OF STRAIN IN THAT BASE, THE INCREASE IS ALSO ESSENTIAL.

THIS YEAR'S PROPOSAL PUTS A STRONG EMPHASIS ON FOUR MAJOR AREAS--BIOTECHNOLOGY, COMPUTATIONAL SCIENCE AND ENGINEERING, GLOBAL GEOSCIENCES, AND BROADENING PARTICIPATION IN SCIENCE AND ENGINEERING.

EACH OF THESE AREAS SIGNIFICANTLY AFFECTS THE HEALTH OF THE SCIENCE AND ENGINEERING BASE. THE FIRST THREE OF THESE STRENGTHEN THE BASE AT KEY POINTS OF LEVERAGE, WHERE MAJOR NEW ADVANCES IN KNOWLEDGE ARE POSSIBLE, AND WHERE THE ECONOMIC EFFECTS ON

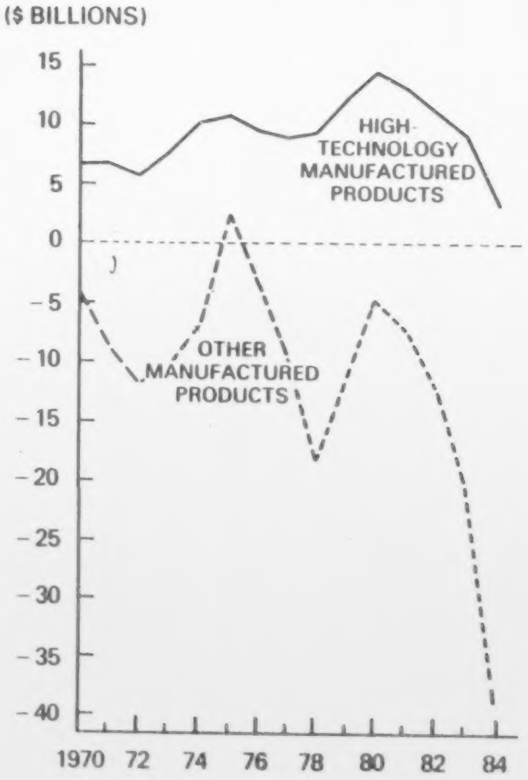
IMPORTANT INDUSTRIES ARE LIKELY TO BE SUBSTANTIAL. THE FOURTH WILL HELP BUILD THE BASE BY HELPING TO ENSURE A SUFFICIENT SUPPLY OF HIGH QUALITY SCIENTISTS AND ENGINEERS FOR OUR FUTURE WORK FORCE.

EACH OF THESE EMPHASES CROSSES DISCIPLINARY LINES IN MANY WAYS, AND INVOLVES MANY OF THE FOUNDATION'S INDIVIDUAL PROGRAMS. SUCH CROSS-DISCIPLINARY EFFORTS ARE IMPORTANT, BECAUSE IT IS OFTEN AT THE INTERSECTION BETWEEN OLD FIELDS THAT THE GREATEST PROMISE LIES.

EACH WILL ALSO FOSTER STILL MORE COOPERATION BETWEEN UNIVERSITIES AND INDUSTRY, AND THAT, TOO, IS PART OF THE SOLUTION WE ARE LOOKING FOR. BOTH SIDES BENEFIT WHEN EACH GAINS THE PERSPECTIVE, EXPERIENCE, AND RESOURCES OF THE OTHER.

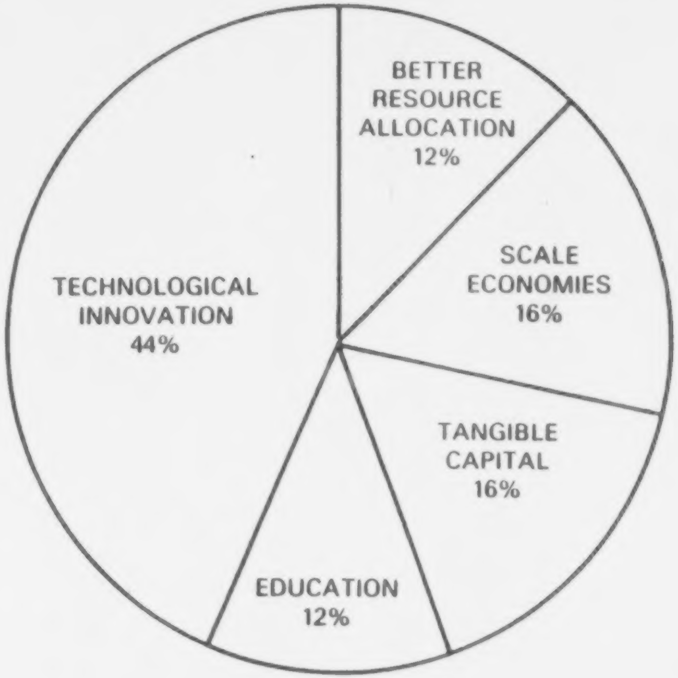
MR. CHAIRMAN, THAT CONCLUDES MY PREPARED STATEMENT. THANK YOU.

U.S. TRADE BALANCE IN HIGH-TECHNOLOGY AND OTHER MANUFACTURED PRODUCT GROUPS, IN CONSTANT DOLLARS

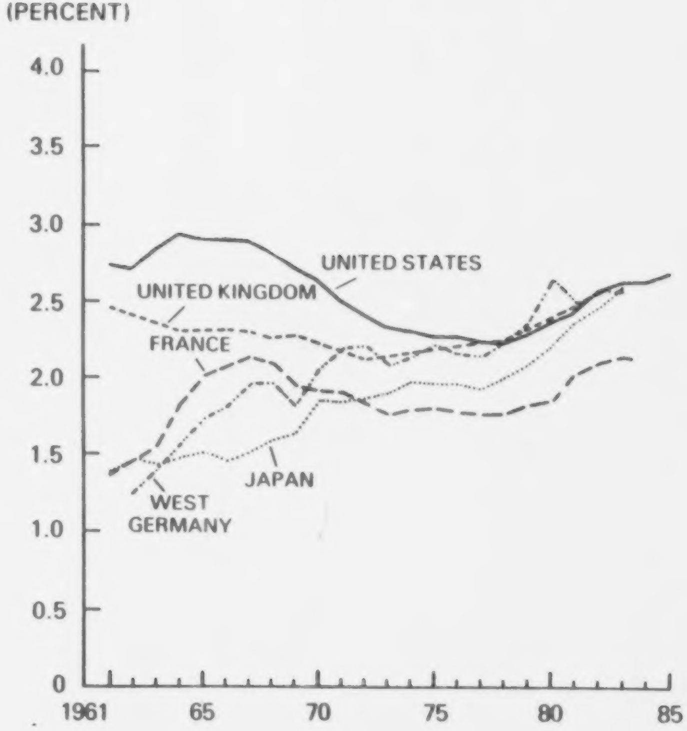


(2)

CONTRIBUTORS TO U.S. PRODUCTIVITY INCREASES



NATIONAL EXPENDITURES FOR PERFORMANCE OF RESEARCH AND DEVELOPMENT AS PERCENT OF GROSS NATIONAL PRODUCT BY COUNTRY



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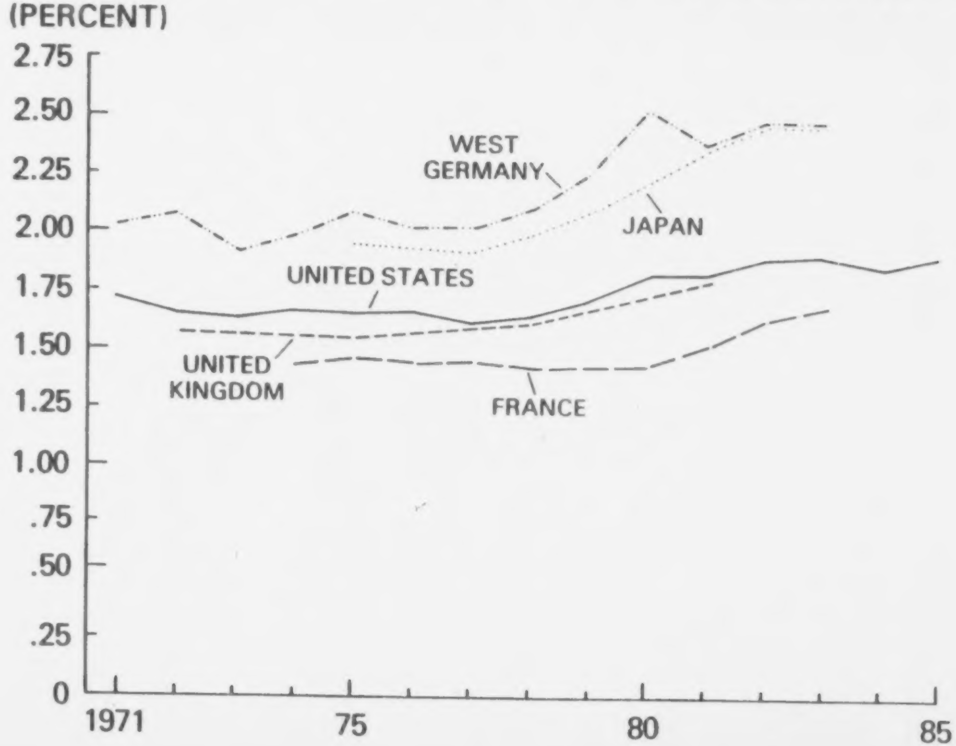
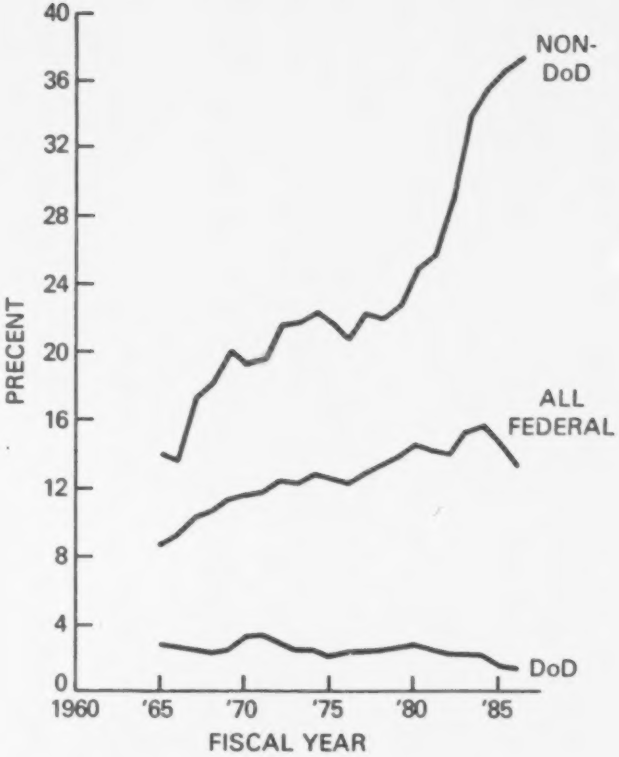
ESTIMATED RATIOS OF NON-DEFENSE R&D EXPENDITURES TO GROSS NATIONAL PRODUCT (GNP) FOR SELECTED COUNTRIES



(5)

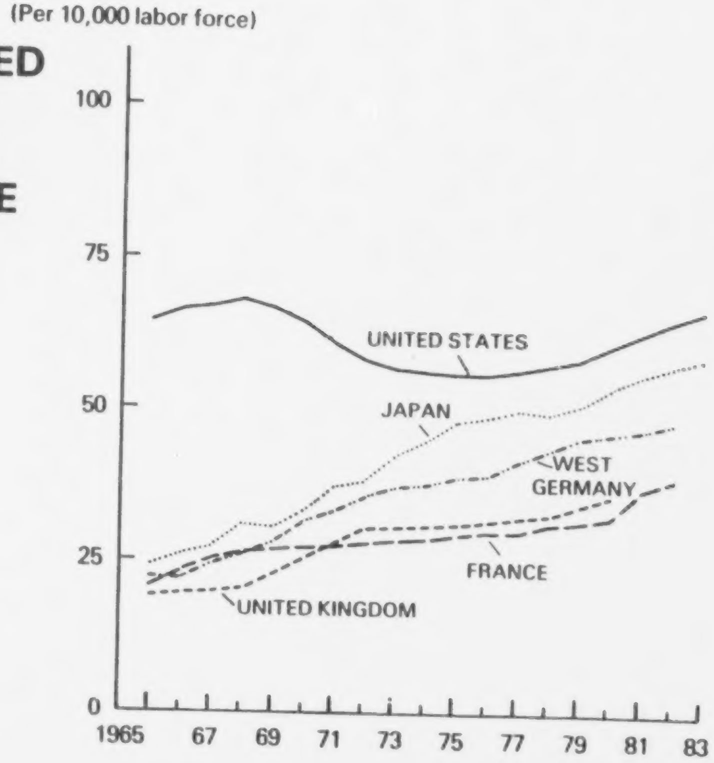
BASIC RESEARCH AS A PROPORTION OF TOTAL R&D BY CATEGORY



Source: National Science Foundation

(6)

SCIENTISTS AND ENGINEERS ENGAGED IN RESEARCH AND DEVELOPMENT PER 10,000 LABOR FORCE POPULATION BY COUNTRY



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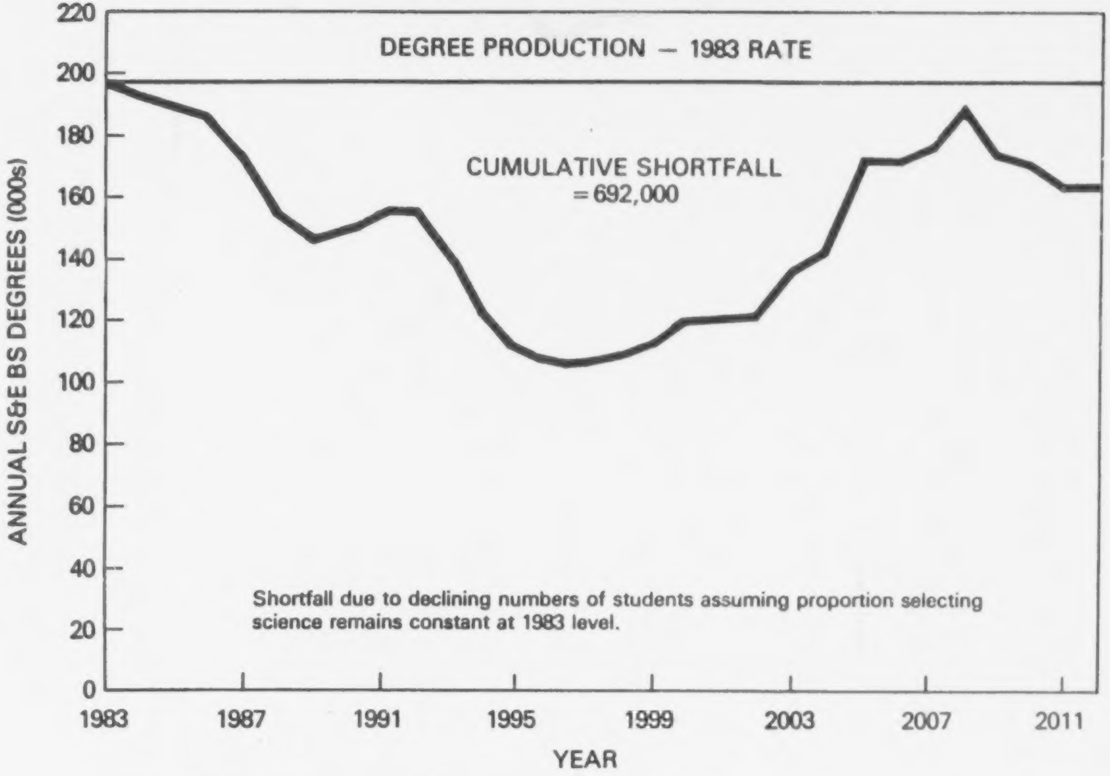
S&E BS PRODUCTION

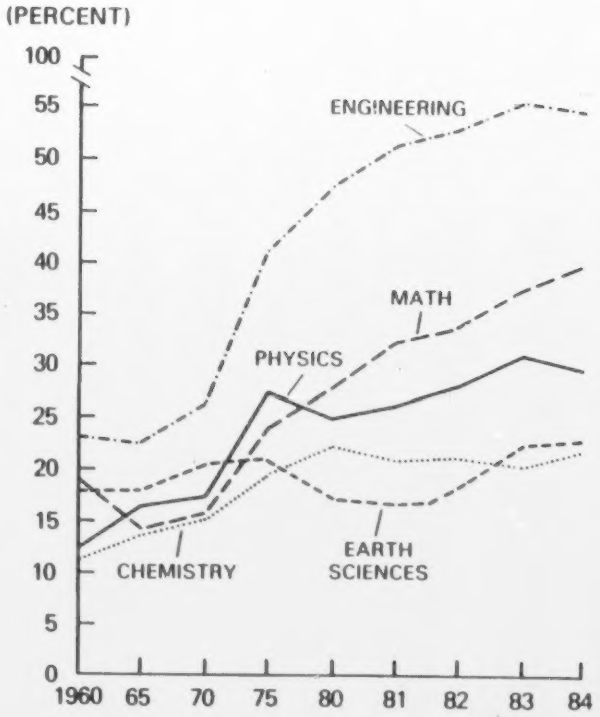


Source: National Science Foundation, based on Census data.

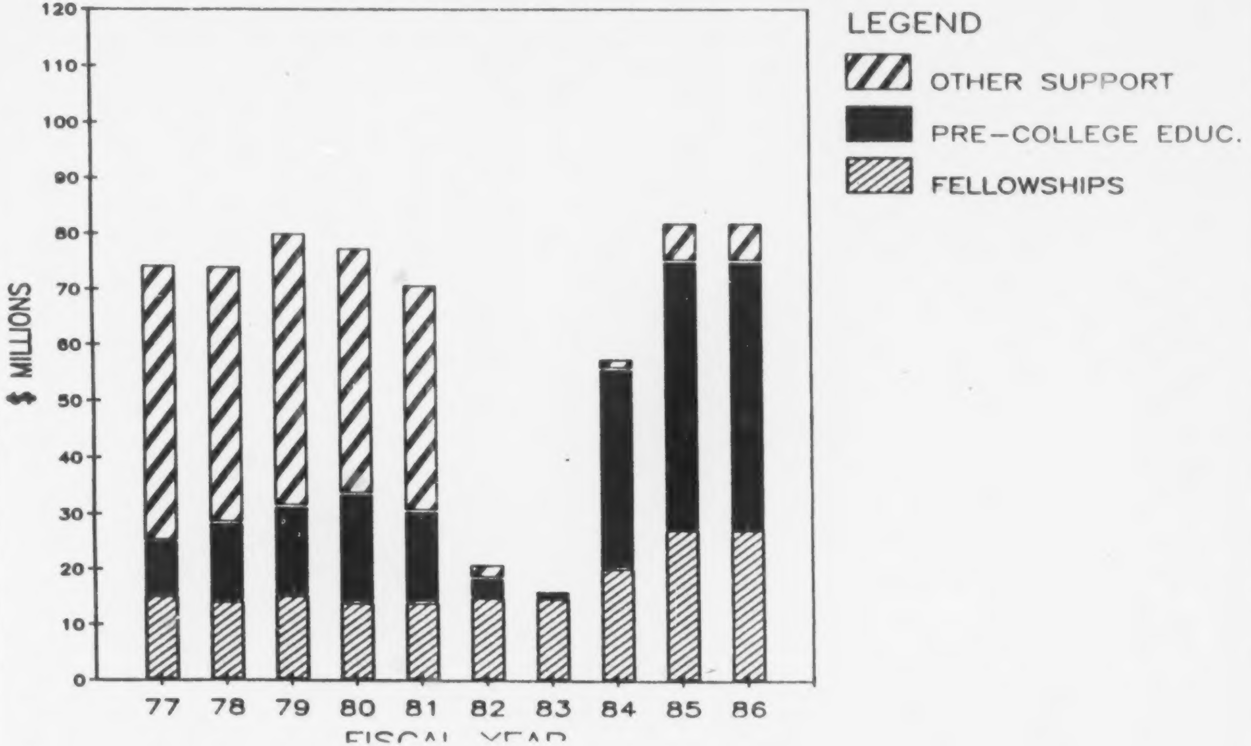
(9)

DOCTORAL DEGREES AWARDED TO FOREIGN STUDENTS AS A PERCENT OF ALL DOCTORAL DEGREES FROM U.S. UNIVERSITIES, BY FIELD

ENGINEERING, MATHEMATICS,
AND PHYSICAL SCIENCES

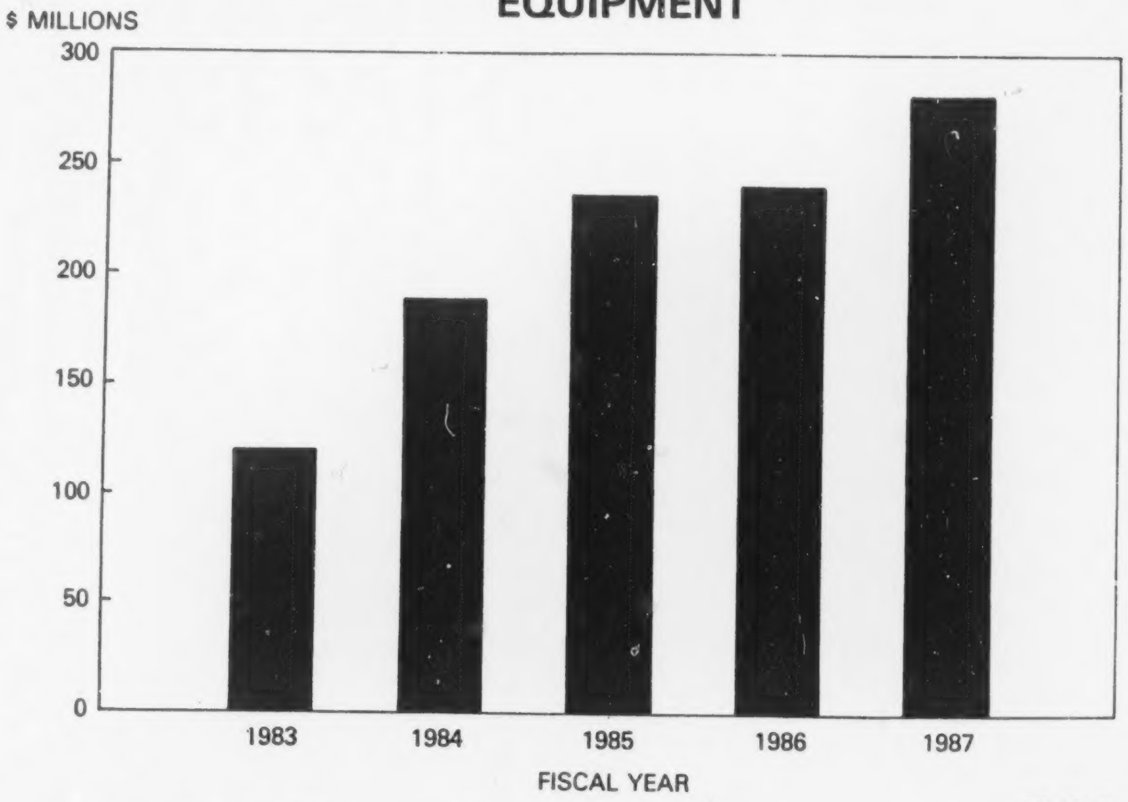


SCIENCE AND ENGINEERING EDUCATION OBLIGATION TRENDS FY 1977 – FY 1986



(11)

NSF EXPENDITURES FOR RESEARCH EQUIPMENT



O/D 86-142

Source: National Science Foundation, Office of Budget, Audit and Control

Senator Pell [presiding]. Thank you very much, Mr. Bloch, and in the absence of our chairman, we will get on with questions now, with his approval.

Just to start out, we will try to confine ourselves to maybe 10 minutes each.

I read somewhere that in Japan they have as many engineers as we do, and about half the population. And I am wondering if many of our problems today are not related to the point you made, that we need more engineers. I am also struck by the fact that we have such a crisis in our insurance business, insurance in industry and liability at this time. I am also struck by the fact that we really have more than enough doctors; it is just a question of where they are.

I am wondering if you would agree from an overall viewpoint that as a nation, we are producing too many lawyers and doctors and too few scientists and engineers and maybe MBA's?

Mr. **Bloch**. Thank you, Senator Pell.

Senator **Kerry**. That is called a softball.

Mr. Bloch. I am not sure that I want to comment on whether we are producing too many doctors, because we all need doctors. We surely do produce too many lawyers. We do not all need lawyers, that is for sure. [Laughter.]

But let me turn to the serious part of your question——

Senator **Pell**. My question is serious. I think we have too many of them.

Mr. **Bloch**. Well, I think you are absolutely right; we are not attracting enough people to science and engineering, and I think both of these fields are required.

Let me talk about Japan for a second. It is not quite right that Japan has as many engineers as we have. On a per capita basis, they have more engineers than we have. However, in certain fields, like electrical engineering, which is a very important field, not just because I am an electrical engineer but on an objective basis, they are outproducing us on an absolute number basis.

So they are focusing very heavily on certain engineering disciplines that are important to their high-technology industry and Japan's future.

Second, I want to address a question asked many times: "What do they do with all those engineers?" One thing that they do well, which we have not done very well, is use engineers in large numbers on the manufacturing floor and in manufacturing engineering. I think that probably explains to a great extent the advances which Japan has made in manufacturing and why it is broadening its market share in many areas like semiconductors, computers, and consumer and industrial products of all types.

Senator **Pell**. And it is part of their industrial pattern where they do not have the differentiation between white collar and blue collar quite as emphasized as we do, where in plant after plant, you go around, and the dirty, unair-conditioned part of it is the blue collar part, and then you get into the nice little air-conditioned part, and that is the white collar end of it. I think they have less of a distinction between the two.

Moving to another area, in a private meeting a little while ago, we touched on the issue of science education in high schools. I wonder if you could bring me up to date on the Foundation activities in this area?

Mr. Bloch. We have, as you know, the Science and Engineering Education Directorate, which has focused heavily on high school education for mathematics and science.

The reason for this is simple: we felt that we had to go to the bottom of the pipeline, so to speak, and make people aware of what science and mathematics is, and lay the foundation at that particular level so that later they can use that foundation as they enter college and pursue a career.

Many of our programs have to do with materials development; some with education of the teachers themselves; and others with the networking of the various teachers. Most of the programs involve college and university professionals in the process itself, as well as in developing materials, to capture the input from people doing research, to reflect new insights into the teaching material.

Senator Pell. Thank you very much.

Incidentally, returning for just a moment to the question of the number of doctors, the problem is not the quantity; the problem is the distribution. And the point that I am driving at here is that on a per capita basis, we have more than enough, but they are focused in certain areas of the country, leaving other parts of the country underserviced in that regard.

Finally, I would be curious if you would favor undertaking joint projects in math and science education with the Department of Education?

Mr. Bloch. We have had a number of discussions with the Department of Education. We are cofunding a number of programs in the informal education area, namely TV programs, including a new one that is coming up in the fall on mathematics, "3-2-1-Contact," which has been in existence for some time, and other programs of this sort.

Dr. Shakhashiri, the Assistant Director for the Science and Engineering Education Directorate, Dr. John Moore, the Deputy Director of the Foundation, and I spent some time some weeks ago with Dr. Bennett of the Department of Education and his staff to explore ways to cooperate better in the future. We have a general agreement to help the Department staff their activities properly. They do not have enough staff today to handle the mathematics and science area. We are willing to help by giving people from the Foundation or recruiting people for them. Also, we can make sure that our programs do not overlap and that they are symbiotic to get the most out of the relationship. So we are starting on a more intimate kind of a relationship with that department.

Senator Pell. Thank you very much.

Finally, the National Science Foundation established an Industry-University Cooperative Research Center for Robotics at the University of Rhode Island, and I was curious how that was coming along, and the fact that you are also supporting the establishment of fundamental research centers in different parts of the country, how that program is coming along.

Mr. Bloch. There are a number of industry-university cooperative centers. They are doing well. Many of them are self-sufficient and are no longer getting support from the Foundation because they developed to the point where the industrial support and other support is sufficient to maintain them. Others, however, we are still supporting. So I think in general, these centers have done well. I cannot talk specifically to the Rhode Island Center; I just do not know.

We started the first engineering research centers in 1985, with five centers involving seven universities. We are announcing today the 1986 center grants, which are for six centers involving seven universities. I think from this 2 year activity, it is clear that we are serious about the engineering research center effort. We would have liked to fund many more in 1985 and in 1986, but because of restrictions that we have on our funding, that is all we could fund. We probably would have liked to fund a total of 12 this year. We received initially 100 proposals; about 40 were very good, and out of the 40, 12 were excellent. The cutoff at six was not a quality cutoff; it was a cut-off required because of limitation in budget. The centers are distributed throughout the country and are also distributed as to the subject matter they address.

Senator PELL. Thank you very much, indeed. My regards to you and to the NSF are of the highest order. I look forward to supporting you.

Mr. BLOCH. Thank you very much.

Senator PELL. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator.

We are happy to welcome you here, Mr. Bloch. I apologize for not being here right at the beginning of the meeting, and I want to thank my good colleagues, Senator Pell and Senator Simon, for filling in for me.

One of the recurring concerns of this committee has been the geographic distribution of funds, or at least I have raised it almost every year since I have been here. I first raised this issue in 1977 when four States were receiving a total of 42 percent of the total NSF funds. I think we all want to preserve the high quality of the NSF grants, and we believe that peer review is essential for that purpose.

But I still believe that we waste a lot of talent and a lot of scientific potential if we do not encourage the development of scientific resources all over the country.

So, would you tell the committee what efforts NSF is currently undertaking in addition to EPSCOR in this regard?

Mr. BLOCH. Well, this question has come up in every hearing so far, so it is very topical.

The CHAIRMAN. That is right.

Mr. BLOCH. And you also know that we have considered that problem in the Foundation very seriously over the years. You mentioned EPSCOR. EPSCOR is one of the programs that tries to take some of the States that are participating at a relatively low level, and bring them up to a more acceptable level of participation. In this particular budget, we are asking again for funding for this program. We are looking at 12 States that are competing for these funds, and probably 7 or 8 of them will be funded. So we are very conscious of our obligations.

Many of the programs that we have, like in the undergraduate area and in the undergraduate instrumentation area, lend themselves to geographic distribution because the requests come from various types of institutions and from all parts of the country. So I think we have a good distribution in some of these programs.

I would like to show you, if I may, a series of four charts that put the geographic distribution in quantitative perspective. And I would like to show you how the Foundation stacks up.

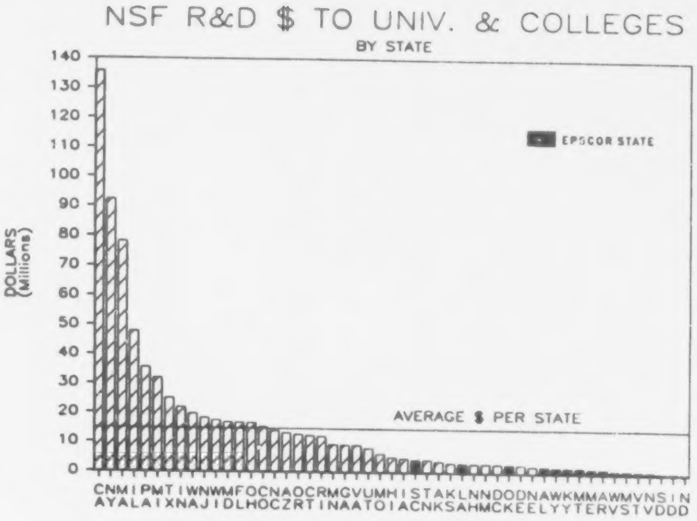
[The charts referred to follow:]

NATIONAL SCIENCE FOUNDATION ANALYSIS
GEOGRAPHIC DISTRIBUTION OF AGENCY FUNDING

The following charts are all based on the relative distribution of 1983 R & D funds of the National Science Foundation. The measure chosen to distribute these funds differs; the first two are commonly used to measure the relative equity of NSF's funding patterns against some standard other than science. The fourth, and last, is a presentation of the impact of NSF's standard for research excellence on its funding distribution. The third, the number of scientists and engineers, is an attempt at a halfway measure.

The substance of the analysis displayed by Charts 2, 3, and 4 is that when viewed aganist a number of different, but significant parameters, the distribution of NSF funding is clearly more equitable than Chart 1 would lead one to conclude. The data on Charts 2, 3, and 4 show that almost half of the states exceed or meet the average funding level indicated. Further, in many of those states where funding levels are significantly below the average, NSF is making a concerted effort to assist in the improvement of the scientific and engineering research and education infrastructure through such activities as the Experimental Program to Stimulate Competitive Research and enhanced support levels for undergraduate institutions in both the research and education activities of the Foundation.

CHART 1 of 4



NSF R&D FUNDING TO UNIVERSITIES

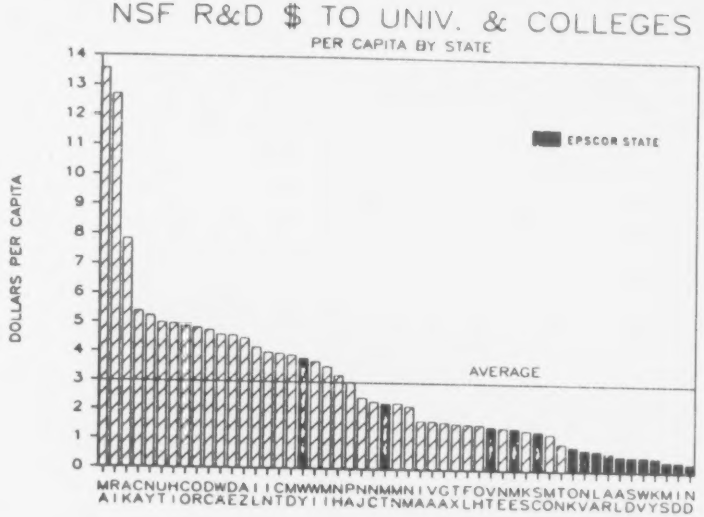
AND COLLEGES BY STATE

- States are arrayed in order of receipts of 1983 NSF R&D dollars to universities and colleges.
- California, New York, Massachusetts, and Illinois are the high recipients.
- EPSCOR states represented by solid bars.

SOURCE: National Science
Foundation Feb. 1986

CHART 2 of 4

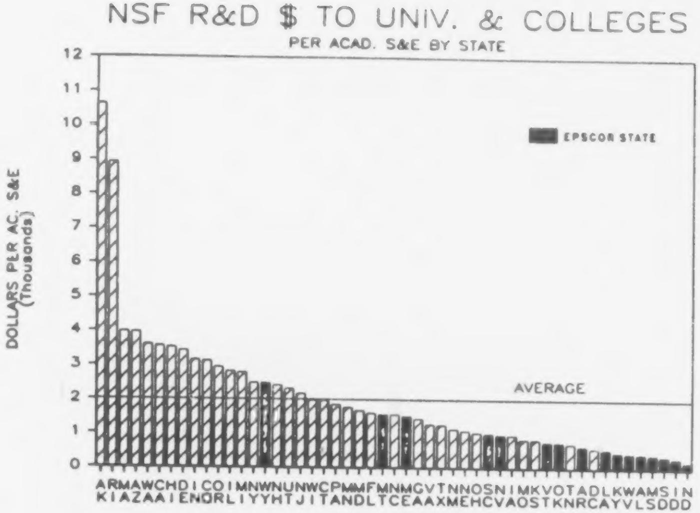
NSF R&D FUNDING TO UNIVERSITIES AND COLLEGES PER CAPITA BY STATE



- o Same NSF funding data divided by each state's population. Plotted in in descending order of per capita state funding.
- o The high states are Massachusetts ($13.56/capita), Rhode Island, Alaska, California, New York, Utah, and Hawaii.
- o States represented by solid bars are the states being assisted through EPSCOR.
- o Twenty-two states exceed or meet the average including such states as Delaware, Arizona, Wyoming, and New Hampshire.

SOURCE: National Science
Foundation Feb. 1986

CHART 3 of 4



NSF R&D FUNDING TO UNIVERSITIES AND COLLEGES PER ACADEMIC SCIENTIST AND ENGINEER

- NSF R&D funding divided by the number of academic scientists and engineers in each state, arranged in descending order.
- The high states are Alaska, Rhode Island, Massachusetts, and Arizona.
- States represented by solid bars are the states now being assisted through EPSCOR.
- Twenty states exceed or meet the average including such states as Colorado, Minnesota, and Utah.

SOURCE: National Science
Foundation Feb. 1986

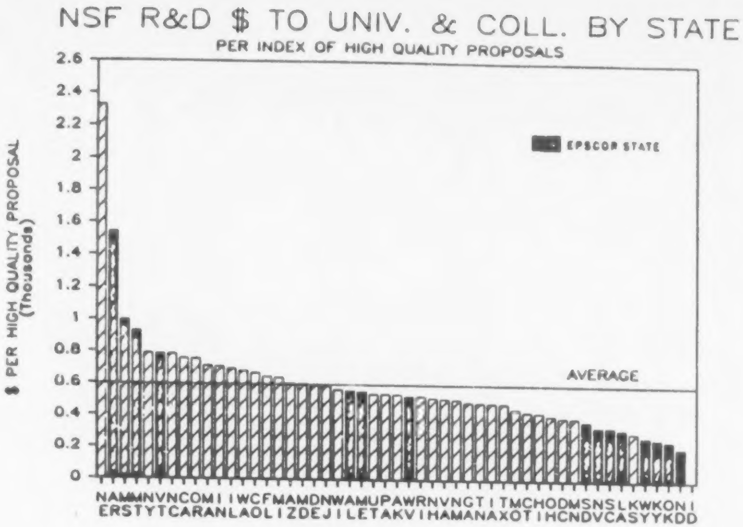


CHART 4 of 4

NSF R&D FUNDING TO UNIVERSITIES AND COLLEGES DIVIDED BY NUMBER OF HIGH RATED PROPOSALS PER STATE

(PROPOSAL QUALITY INDEX)

- NSF R&D funding per state divided by a sample of high rated proposals from each state in the years 1980, 1981, and 1982.
- The chart shows that, in general, NSF's allocation of R&D obligations to academic institutions is proportional to the highly rated proposals coming from a state.
- States represented by solid bars are the states being assisted through EPSCOR.
- Nineteen states exceed or meet the average including such states as Nebraska, Arkansas, Mississippi, Montana, Florida, and North Carolina.

SOURCE: National Science
Foundation Feb 1986

The CHAIRMAN. I can see you were prepared for this question.

Mr. BLOCH. Well, I mentioned a minute ago that I have done it in every hearing. And I think it is an important subject matter, and, Mr. Chairman, if you had not brought it up, I would have brought it up because I think we should talk about it and look at it in a quantitative way.

If you would turn to Chart 1, you see the 50 States by name and then the distribution of the R&D dollars of the Foundation, distributed by States. You see high peaks on the left, then after about 10 States it dribbles off almost to zero. This chart takes the total R&D dollars and divides them by 50. I suggest that this is too simplistic a way to look at it, because it has nothing to do with science and engineering or how science and engineering personnel and how industry is distributed throughout the States, or what the population of the States is. This is usually what is quoted when people say the Foundation has not considered distribution in a serious way.

Let me ask you to turn to chart 2. Take the same R&D dollars of NSF and show them up now on a per capita basis by State. The picture changes dramatically. Some peaks are still on the left side like Massachusetts and Rhode Island but then it drops off in a more gradual way. I would suggest that this is a better way to look at it, where one takes into consideration the population of the States.

The CHAIRMAN. But I notice that Utah is only No. 6.

Mr. BLOCH. Yes; you are only No. 6.

Senator SIMON. If the chairman would yield, Utah is ahead of Illinois and Connecticut, I notice.

The CHAIRMAN. Which is only right, I might add. But Illinois and Connecticut used to be ahead of Utah.

Senator DODD. So, someday we will be chairman.

The CHAIRMAN. Yes, someday you will be chairman. [Laughter.]. Do not count on it. But as a matter of fact, I am sure they would treat me as well as I have treated them when they become chairman.

Mr. BLOCH. By the way, Mr. Chairman, let me say this was before our announcement today on the engineering research centers, one of which is going to Utah.

The CHAIRMAN. So Utah will move up more?

Mr. BLOCH. I do not know where you are moving; you can figure that out yourself.

The CHAIRMAN. Well, let me say this. Remember, I am chairman, and I do not see Utah as No. 1 here yet. I still see Senator Kennedy as No. 1 here. Of course, we have a lot to overcome, because with 42 percent of the money, he and Senator Javits took almost all of it when I got on this committee 10 years ago.

Mr. BLOCH. Now, let me move to chart 3. This one essentially again takes the same R&D dollars that the Foundation has and divides it on a per capita basis, but the per capita is based on the academic science and engineering population of each State. You see that the distribution broadens out. You also see, for instance, that Massachusetts is no longer No. 1 as it was in the previous chart. It has been replaced by Alaska. That has to do with the high concentration in one particular institution in Alaska.

Then, if you turn to the last chart, chart 4, which represents the funding to universities and colleges divided by the number of high-rated proposals per State, you see that things follow the average line.

The point I want to make is that the first chart is not a valid way to look at the situation. The second and third ways, per capita by State or per capita by science and engineering personnel per State, are probably a better way to represent it. We are taking all that into consideration. As I said before, many of the programs that we are putting in place will give us a better distribution anyway, because of the subject matter they address and because of the various institutions they address.

Senator DODD. Where is Connecticut on that? I do not even see it.

Mr. BLOCH. Well, Senator, let me see if I can point it out to you.

Senator DODD. There it is, way down there where you can hardly read it. I see it.

The CHAIRMAN. They have so many other things going for them, though.

Mr. BLOCH. You are still close to the average line, which is what I wanted to point out.

The CHAIRMAN. We will include these charts in the record. Mr. Bloch, let me just ask you this. Could you elaborate on the benefits of using research centers instead of awarding individual grants? I notice that NSF is utilizing this centralized approach in several areas besides engineering. Could you just tell us what the benefits are of using research centers?

Mr. Bloch. Over individual grants?

The CHAIRMAN. Yes.

Mr. BLOCH. Well, let me tell you how the research centers came into being. It was recognized that engineering is changing in a dramatic way. The way engineering is done today compared to how it was done 30 years ago is completely different. Moreover, engineering is becoming more of a multidisciplinary activity. It is no longer just electrical engineering or mechanical engineering, or civil engineering, but these various disciplines are interacting with each other.

And there is a higher content of science involved in engineering today than there was in the past. We had to bring the universities up to that level of teaching and up to that level of doing research. The engineering research centers are supposed to help accomplish that. They combine multidisciplinary research, not just using engineering disciplines, but also science disciplines, not only from the natural science areas, but also from the behavioral and social sciences. Engineering research centers also are putting in place instrumentation and equipment that is required and that is becoming very complex and expensive.

So in this field we had to augment the individual principal investigator award and add the center concept. By the way, that is not unique to engineering. It is true in materials research and it is certainly true in biotechnology, and we are addressing the centers concept there also. It has also been true in particle physics for a long time. So I think what you see happening is that engineering and some other sciences are becoming more of a group activity than an individual activity.

We are very concerned about that balance. This does not say that we are no longer giving single investigator awards. The balance, especially in engineering, is shifting into groups, away from the single investigator.

The **Chairman**. Thank you. I have other questions, but I think I will submit them to you.

Mr. **Bloch**. Thank you.

The **Chairman**. Senator Kerry, we will turn to you.

Senator **Kerry**. Thank you, Mr. Chairman.

I am going to hold off on the questions. I have some, and I would like to submit them if I can. I would like to also ask unanimous consent to have a statement put in the record as if read.

The **Chairman**. Without objection, we will do that.

Senator **Kerry**. I would like to say before I go to another committee hearing that obviously, Mr. Bloch, you and NSF are performing a vital function for us. I want to express my personal concern—and, while I share with Senator Kennedy the privilege on this committee of representing the interests of Massachusetts, and we have over 118 colleges and universities that benefit greatly, I do not think the charts, while they show the distribution of money, and while there are some increases, and even in this year's budget an increase, I do not think it tells the story of the critical juncture at which we find ourselves in this country right now.

Now, you have said it. You said it in kind words, and I guess that is one way of doing it. But I wish the President and the administration were putting the kind of energy into this front as they are into some others and the kind of energy of the Saturday talks and the other effort to highlight the real need for underscoring the kinds of solutions to the problems you have cited.

It is not a game anymore. We are in a much more competitive world. We are in a world that is volatile with competition. And other countries are determined, more determined than they have ever been at any time in history to take our markets away from us. And it has always been our technology and always been our research and always been our ability to come up with new markets and new products that has kept us ahead of everybody. That is now threatened. And I am concerned that the administration has not placed the emphasis on nurturing basic civilian research in science and on science education in the future, particularly at the precollegiate level. I am concerned that the President is now without a full-time Science Adviser, one who can represent the scientific community at the highest level of government. And it is no secret to anybody in the scientific community that in the past few years, the role of the President's adviser has been substantially changed from that of a representative of the scientific community into an advocate for the President's policies, particularly for things like SDI. I do not think that is the role, and I do not think that that is what it ought to be. And it is my hope that we are soon going to see a Presidential Science Adviser who is going to represent the broad interests of the community.

Four areas of concern, and I leave you with these very quickly. One, the eroding base of the university research enterprise. Our brightest investigators are working on outdated equipment. I heard you in your testimony talk about curriculum out of date, faculty out of date, facilities out of date, and we all know that there are billions of dollars of expenditure needed to put us where we ought to be.

Second, the whole direction R&D spending has taken in the last two decades, away from civilian, away from basic, into science, into defense, and now, our United States civilian research is way below that of Japan, way below that of West Germany, as you have cited, on a relative basis, and that is unacceptable.

And third, the growing recognition of the whole importance of science in this new world of ours, the competitive world, of the question of competitive ability and capacity to open new markets.

And finally, the fact that we obviously—and I think nowhere has this been more true than in Massachusetts—stand on the threshold of a broad new spectrum of possibilities in microelectronics, in biotechnology, a whole score of things, supercomputers. And yet, we are not doing what is necessary to really generate either the capital formation or the ability of people to make sure that we are going to keep the lead we have there.

So I think your role right now, the NSF role, is critical. I am glad, Mr. Chairman, we are here talking about reauthorization. I want to voice these concerns. I have done so in greater detail in my statement.

I am sorry I cannot remain with you for more questioning. But there is one question I would like to leave you with, and that is: Do you believe that the Director of NSF should double as the Science Adviser to the President in view of what has happened in these last years? I would love to pursue that with you more, but unfortunately, I cannot.

Mr. BLOCH. I can give you a one-word answer: No.

Senator KERRY. Thank you. I just wanted that on the record.

Mr. BLOCH. Can I make one brief additional comment, Senator?

Senator KERRY. Absolutely.

Mr. BLOCH. Let me tell you that over the last 3 or 4 years, primarily because of the Science Adviser, Dr. Keyworth, basic civilian research in universities has been increasing significantly. Now, unfortunately, it has not increased as much as some of the other in R&D areas, especially the "D" part of defense. That is why you saw the drop in the total. But it has been significantly increasing. And I think that the President and the administration have used the Foundation's budget request to make that particular point: the need for increased basic research.

Unfortunately, in 1986, where we also had an increase—not a very large one, only about 6 percent in research and related activities, or 4.5 percent total—we are winding up, because of congressional action and because of Gramm-Rudman, at minus 2 percent over 1985.

The point I want to make is that the administration put on the table last year, as it does this year, a significant increase for the Foundation, but we were not able to get the request through Congress.

Senator KERRY. Didn't you have, however, significant amounts of moneys unexpended for the precollegiate programs?

Mr. BLOCH. Well, there were carryovers from the precollegiate program from 1985 into 1986, but even taking that into account, we wind up in 1986 over 1985 with a minus 2 percent level.

Senator KERRY. Fair enough. Well, I am not going to vote for that.

Mr. BLOCH. Thank you.

Senator KERRY. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Dodd, let us turn to you.

Senator DODD. Thank you, Mr. Chairman.

Welcome, Mr. Bloch, to the committee. First of all, I want to thank you for a letter that you did not send to me, but you sent to Mr. Jordan, the president of Kenyon College, in December of 1985, in which you favorably commented on the idea of trying to do something in the area, along with a for-profit corporation, quasi-independent, for construction of education facilities and the like. I am sure you are familiar with the letter.

Mr. BLOCH. Yes.

Senator DODD. I want to thank you for it.

There was a report that said—and I realize I am picking on one particular area, but it seems to me the costs are so staggering when the estimates have been given, and given the fact that we have gone now a number of years—apparently, 25 percent of the 3,000 colleges and universities in this country have not had any new construction of any major type at all since prior to World War II; another 25 percent, you have to go prior to 1960. So over half of the institutions have gone almost a quarter of a century when facilities construction is so important.

The estimates I have heard are that if we were to put a dollar amount on the amount of work that needs to be done to put our facilities up to the times is somewhere between $40 and $80 billion. That is a big spread. Can you narrow those numbers down at all? Are they way off base?

Mr. BLOCH. As you indicate Senator, you can hear almost any number. The number that people primarily cite is somewhere between $20 and $50 billion. But it does not matter, you know; it really does not matter. Nobody has an accurate number.

The Foundation is undertaking a program, at the behest of Congress, to find out through a survey what the real situation is. We are starting that now, and we will have some results back by the end of the year. It is a quick survey, by the way; it is not a very profound one. But then, next year——

Senator DODD. Well, let me ask you this first, so we understand each other. Is that survey being done to determine whether or not there is a problem, or——

Mr. BLOCH. No, to quantify it. No one argues that there is a problem; to quantify the problem, so that you do not have to use numbers like $50 to $80 billion, and I do not have to use numbers like $10 to $50 billion, when neither of us quite knows what the right number is.

Senator DODD. We know at this point that the number is——

Mr. BLOCH. The number is very large.

Senator DODD [continuing]. Very large. Forty billion would probably be on the low side?

Mr. BLOCH. I would say it probably describes it, yes.

Senator Dodd. The low side? Is that your answer? I am sorry.

Mr. Bloch. No, I cannot speak to that. I do not know if it is on the low side, but I think it is probably a representative number.

Senator Dodd. All right. Can you try at all—and I realize again the study will tell us more in this area—but what percentage of the total of that figure, roughly, is the need in terms of research instrumentation, equipment, and what percentage would be for bricks and mortar kinds of things?

Mr. Bloch. I thought the number that you were focusing on was bricks and mortar. There is another number which is much better documented and which we know more about, for equipment and instrumentation, which is somewhere between $2 and $8 billion.

Senator Dodd. OK.

Mr. Bloch. OK. I want to keep these two subjects separate, because they should be treated separately.

Senator Dodd. Now, you did comment, and you are familiar—I presume people from your staff were here during the markup of the higher education bill. I did not offer the amendment to establish this for-profit corporation, or quasi-independent organization for facility construction, because we wanted to do a little more work, I think, with the people on the committee to make sure we understood it.

But let me just ask you today, because I did put your letter into the record—I presume you have taken a look at the proposal and I would like to get your comments on it, if I may.

Mr. Bloch. Right. Let me just say a couple things about it. First of all, I think a concerted effort on this problem is required.

The second point I want to make is that we should not make that effort and then deduct it from the research budget. This has been proposed before, in Congress in the facility bills of the House Science and Technology Committee, where Government would put some money into facilities in the first year, then take it away from the research and development base in future years. I cannot subscribe to that, because we have equal problems in the research area and in the people area to those that we have in the bricks and mortar area and in the instrumentation area.

And therefore, the proposal that you are citing has the benefit that it does not do that, that it depends on the private sector, the marketplace and leveraging to attack this problem, and I think that is good.

The third point I want to make is that whatever the solution is and whatever we put in place, we have to put the universities in a position where they never get into this kind of a bind again. They have to look at the depreciation of their bricks and mortar and the depreciation of their equipment seriously and set aside funds so that 10 or 15 years from now we don't have the same problem all over again.

I think a long-term solution has to be put in place, and I think we have to make sure we are bridging the gap between that long-term solution and where we are today.

Senator Dodd. One of the concerns that was raised about this—and in fact, our chairman here highlights it as well in his going back and commenting on the distribution of funds under NSF—is a lot of times, the feeling is that these are political decisions more than substantive decisions. But one of the things we have tried to do in the bill is establish an independent commission that would evaluate the requests for support of the 3,000 colleges and universities, an estimate that 300 or so are affluent enough, if you will, in their own right, through endowments of various kinds that they can undertake capital construction without necessarily going to even something that would be quasi-independent. And, rather than have an institution or a body or an agency that could be subject to that kind of effort, the commission is the one that would make those decisions on whether or not an institution should actually go that route in qualifying for those funds.

Mr. Bloch. I think it is a good idea to keep it out of the political process and put it on the financial quality and the need of an institution.

Senator Dodd. Yes. And you may recall as well, we were talking about a total Federal commitment over 5 years amounting to $125 million, or $25 million a year. The private sector would match that, and the corporation itself, Sally Mae, would be contributing $5 million. We were told from an actuarial standpoint that that $275 million would leverage between $3 and $5 billion, which would allow us to get that program underway.

Mr. Bloch. It is important that something like that be done, because some of the tax provisions being talked about would restrict many of the universities and colleges even further from access to capital funds. So I would encourage that that be done.

Senator Dodd. Mr. Chairman, thank you very much.

Thank you, Mr. Bloch.

The Chairman. Thank you, Senator Dodd.

Are there any other questions?

I am going to submit my questions, and they will be extensive. Also, several Senators have requested that their statements be included in the record. Without objection, we will include them at the appropriate place.

[Responses of Mr. Bloch to questions submitted by Senators Hatch, Stafford, Kennedy, Pell, Simon, and Kerry and additional statements submitted for the record follow:]

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ORRIN HATCH

GRAMM-RUDMAN-HOLLINGS

Question: Obviously, the March 1 Gramm-Rudman-Hollings reductions have had an impact in nearly every area of government activity. What has been the effect of the FY 86 cut in terms of NSF's programming?

Answer: The National Science Foundation was subject to the full 4.3% sequestration required by the Gramm-Rudman-Hollings act in FY 1986. The net result is a 1986 NSF budget of $1.458 billion in FY 1986 appropriated funds plus $31.5 million in FY 1985 deferred funds, or about 2% below the actual Fiscal Year 1985 obligational level.

Even in the face of these reductions, it is essential to sustain moderate growth in high-priority areas such as mathematics research; advanced computation; Engineering Research Centers; and special programs for women, minorities, and other under-represented groups in science and engineering research and education. As a result, other NSF activities must absorb a slightly larger share of the total reduction.

To cite specific examples, we expect that about 200-250 fewer new awards will be made in FY 1986 because of G-R-H reductions. Existing grants and contracts have also been subject to reductions; the number of operational ships in the academic research fleet has been reduced; two coordinated experimental projects in computer research are being phased out, as is one Materials Research Laboratory; research centers in astronomy and atmospheric sciences have reduced the size of their staffs. The cap on education allowances for NSF Fellowship recipients has been reduced from $6000 to $5250. Construction projects and major facilities upgrades have been stretched over a longer period, resulting in lower expenditures this year but an increase in total cost over the life of the projects.

Question: How would you cope with a reduction in the requested budget for FY 87, of say, $100 million? I know you hate to think about that possibility -- so do we, as a matter of fact -- but, it is important to have your views on this.

Answer: At any given level, the NSF budget represents a carefully balanced set of plans. Any significant change--and a reduction of $100 million would indeed be significant--requires that we reassess the entire budget in the context of the available resources to make sure that essential balances remain. For example, we are concerned about balance among the scientific and engineering disciplines, between new and continuing projects and established and young investigators. We look at student support, at investment in facilities and equipment, and at balance among individual investigator efforts, group and multidisciplinary projects, and large scale facilities and centers. Thus we cannot simply cut a few items which total $100 million without reference to their impact on the rest of the science and engineering research and education effort.

In FY 1987, even with a reduction of $100 Million, we would retain as much emphasis as possible in the thrust areas which we have identified as especially ripe for growth, but we could not sustain the level of effort proposed in fields such as biotechnology, computational science and engineering, and global geosciences. Our plans to expand NSF efforts in support of undergraduate education would have to be reexamined in light of the total resources available. We have already slowed construction and upgrading of several facilities--the Very Long Baseline Array; Cornell Electron Storage Ring, and others--and have decreased the rate of planned investment in Engineering Research Centers. We would take another hard look at these programs, but in general, further reduction of support for these activities may bring their viability into question.

A reduction of $100 million would carry very difficult choices. On the heels of a FY 1986 budget which is 3% below 1985, this would be a serious reversal of the improvement in support for university-based fundamental research put in place in the 1982-85 period with the support and encouragement of this Committee.

MONITORING MAINSTREAMED PROGRAMS

Question: I am pleased to note you have maintained or increased the target expenditure levels for several of the cross-directorate programs, including women and minorities programs and undergraduate research. These targets, however, are meaningless if NSF cannot track the awards adequately. Are the awards and their amounts in these programs available to the Committee?

Answer: The Foundation has moved forthrightly to solve the problems involved with tracking and monitoring proposals and awards to the cross-directorate programs. In June 1985, the Director of NSF established a task force to examine the administration of these programs and to make recommendations for improvement in existing policies, practices, and procedures. One of the recommendations of the task force was that NSF make more effective use of its internal computerized information systems to better coordinate and monitor the cross-directorate programs. While improvements are still being made, it is now possible to get a listing of all cross-directorate program awards and their amounts from the NSF computer system. This listing is available to the Committee upon request.

SCIENCE EDUCATION

Question: Last year, during the hearing on the FY 86 Authorization Bill, I asked you how the Foundation was complying with Title I of the Education for Economic Security Act. We had some disagreement at that time over the interpretation of a few provisions. Since we have reauthorized the Math-Science Education Bill, I'd like to ask you again about NSF's implementation of this legislation. First, I'd appreciate your explaining for the Committee how the Science and Engineering Education Directorate has structured the precollege level programs. Second, please provide us with a status report on the distribution of awards for these programs.

Answer: The precollegiate level programs in SEE are organized within three divisions: the Division of Teacher Preparation and Enhancement, the Division of Materials Development, Research, and Informal Science Education, and the Office of Studies and Program Assessment. The structure and distribution of awards for each area is:

> The Division of Teacher Preparation and Enhancement houses four programs, two of which are specifically authorized in the Education for Economic Security Act.
>
> The Teacher Enhancement program is the present incarnation of the "Teacher Institutes" with some added features, based on assessment of past experience, to make them even more effective and far reaching in their consequences.
>
> The Presidential Awards for Excellence in Science and Mathematics Teaching program honors outstanding secondary (7 - 12) school science and mathematics teachers as a means to raise the prestige of the profession as a whole and supports the continuing creative teaching of the awardees.
>
> The Teacher Preparation program provides support for developing innovative programs and creative new materials for the preservice preparation of elementary, middle, junior high, and senior high school teachers of mathematics, science, and technology.
>
> The Science and Mathematics Education Networks program provides support to promote the development of ongoing linkages, partnerships, and sharing of resources which result in positive impacts on science and mathematics teachers and teaching--ultimately improving student learning.

FY 1985 History

	Enhancement	Preparation	Networks
Proposals Considered	475	121	47
Awards	127	25	16
$ Requested (millions)	125.67	67.05	20.35
$ Awarded	15.54	6.66	1.34

The statistics will look very similar for FY 1986 with award amounts about 10% higher, reflecting a $2 million budget increase for these three programs from FY 1985 to FY 1986. The Presidential Awards program has a budget of $1 million.

The Division of Materials Development, Research and Informal Science Education includes four programs which enhance precollege science education on a number of levels. One of these programs, Informal Science Education, responds directly to one of the functional objectives of the Education for Economic Security Act, i.e., "the enhancement of public understanding of science and engineering through informal education activities using a variety of mediums such as broadcasting, museums, clubs and amateur science societies" (Title I, section 102.)

The distribution of awards for division programs is as follows:

	No. of Awards FY 1985	$ Awarded FY 1985
Instructional Materials Development	36	$5,982,122
Research in Teaching and Learning	29	$1,999,313
Informal Science Education	25	$7,198,291
Applications of Advanced Technologies	24	$7,545,697
Totals	114	$22,725,418

This funding pattern places primary emphasis and support on two major programs that address major short-term improvement in both in-school and out-of-school learning. Balanced with this are two longer-term research investments: in our understanding of the math/science learning process, and in the state of the art of advanced teaching and learning technologies.

The Office of Studies and Program Assessment supports projects designed to measure the status and conditions of precollege science and mathematics education and to evaluate programs within the Science and Engineering Directorate. In FY 1985 this office funded 13 projects for a total expenditure of $1,747,713. In FY 1986, we anticipate funding 16 projects at a total cost of 3,564,000.

Question: Several recent reports have emphasized the essential contribution of undergraduate education in the preparation and training of scientists and engineers as well as in the scientific literacy of our Nation. How is the Foundation addressing the need for undergraduate research and education support? I hope the Foundation is not segregating undergraduate support into one directorate, but is using the Science and Engineering Education Directorate to help monitor and assist the efforts of the research directorates.

Answer: The Foundation is attempting to address the needs of undergraduate research and education in several ways. For example in FY 1987:

o Undergraduate research participation will be expanded and strengthened;

o Imaginative approaches to individual faculty development will be encouraged; and

o More support will be provided for instructional equipment.

Support for undergraduate activities is provided through both the disciplinary research directorates and the Science and Engineering Education Directorate. In FY 1987, the Foundation intends to augment its ongoing undergraduate activities by $13 million above a base of more than $50 million.

Question: Excluding the College Science Instrumentation Program, is NSF receiving significant numbers of research proposals from predominately undergraduate institutions?

Answer: As a result of active stimulation of the undergraduate research community over the last two years, a significant number of proposals are being submitted. In an average year, the Foundation receives about 3,500 research proposals from faculty in predominantly undergraduate institutions. With 871 awards last year, the success ratio was 25 percent. Total research support at predominantly undergraduate institutions increased from $29 million in FY 1983 to $47 million over the last two years.

Question: How do you disseminate information about these undergraduate target programs?

Answer: Information dissemination on targeted programs is done in a variety of ways. The primary mechanism is through program announcements. For example, this year over 12,500 announcements on the Research in Undergraduate Institutions (RUI) program were distributed to undergraduate faculty and administrators. This program is the centerpiece of the Foundation's effort to support research in undergraduate schools. In the last two years, articles and announcements have been placed in professional journals and newsletters and 57 formal outreach workshops have been given Nation-wide by NSF staff to over 3000 faculty in 25 states, with 350 institutions participating. Internally, information about targeted programs is provided through briefings with program officers and through a system of monthly and quarterly reports on progress being made by each division toward the funding targets established for the current fiscal year.

NATIONAL SCIENCE WEEK

Question: I was pleased to sponsor the Senate resolution for National Science Week, which passed the Senate last Friday. I agree that this special week will help bring the wonders of science and technology to all Americans. What is your estimation of the impact of an effort like National Science Week and what is the role of NSF in promoting it?

Answer: National Science Week was conceived as a nationwide effort to make Americans more aware of the importance of science in their daily lives. The primary focus of the Week is on young people. Grassroots involvement is the cornerstone of the Week. The first National Science Week, May 12-18, 1985, resulted in the active participation of nearly a thousand organizations--corporations, community groups, science and professional organizations, research centers, museums, schools and universities--working individually and cooperatively to provide educational and participatory activities.

Last year's effort, coordinated by the National Science Foundation, was defined by a great diversity of activities, all with the goal of increasing public awareness and understanding of science, mathematics, and technology. Tens of thousands of people of all ages participated in programs ranging from the serious and scholarly to the entertaining. Events included special science and math competitions, open house events at research facilities, teacher workshop and recognition programs, science fairs, and lectures, museum exhibits and a variety of media events. Public Service Announcements (PSAs) were produced by prominent spokespeople such as Don Herbert (TV's Mr. Wizard) and Sally Ride and aired on national television; articles were carried by newspapers, magazines and professional journals. Particular attention was concentrated on activities in ten cities. A summary of their activities follows:

SEATTLE - Seattle's Museum of Flight helped sponsor a design competition called the Second Great International Paper Airplane Contest.

PHILADELPHIA - A unique approach here was the National Dinosaur Short Story/Essay Contest sponsored by the Academy of Natural Sciences. Students from grades 1 to 12 entered short stories and essays on almost every type of dinosaur known. Winners were announced as part of an NSW lecture on dinosaurs at the National Geographic Society, Washington, DC. Noted paleobiologist Jack Horner, an NSF grantee, gave the lecture.

PITTSBURGH - The Carnegie Institution's Regional Center for Science Teachers hosted a full week of events, among them an awards dinner and a science education panel involving local educators. Riverside workshops for students included experiments in water analysis, pollution control, and freshwater biology.

MILWAUKEE - This city sponsored one of the Week's largest Science Fairs: "SCI-A-RAMA," hosted by the Milwaukee Public Museum involving 10 local schools, and aided by local media coverage.

CHICAGO - In a joint program with the Museum of Science and Industry, Columbia College organized lab and nature tours and showed science videotapes and presentations to students and teachers. Abbott Laboratories and Sigma Xi, the honor society for scientists, planned student essay contests, an "open house" at research facilities, and teaching workshops.

SALT LAKE - The University of Utah and the Terra Technology Company hosted a week-long agenda for students, teachers, and the general public. Events included planetarium displays, magic shows by the university's chemistry department, and demonstrations of aircraft and aerodynamics through flight simulators.

NEW YORK - The New York Academy of Sciences adapted its successful "Scientists in Schools" outreach program to National Science Week, involving 200 member scientists.

Washington, DC's Benjamin Banneker High School (named for the noted Black scientist and inventor of the Revolutionary era) held a paper airplane contest - a smaller version of the event in Seattle.

Finally, honoring National Science Week from outer space, Senator Jake Garn (R-UT) flew a paper airplane aboard the space shuttle CHALLENGER as part of the "Toys in Space" program. The paper airplane carried the NSW symbol and is now exhibited at the Smithsonian Air and Space Museum.

For 1986, plans are in place for National Science Week to take place during the week of May 11-17. As you noted, the Senate has already passed the commemorative resolution for 1986. It is hopeful the House will soon consider this legislation. Major plans include the development of multidisciplinary activity packets for use by 12,000 elementary and junior high school students throughout the country, compiled with the help of professional, education and scientific organizations, and the production and dissemination of publications and materials to aid grassroots involvement. Again, activities will occur all across the nation, with special events being planned for Washington, DC. Corporate sponsorship for National Science Week 1986 is provided by the Amoco Foundation, the Atlantic Richfield Foundation, the Dow Chemical Company Foundation, the DuPont Company, the Eastman Kodak Company, the General Electric Foundation and International Business Machines, Inc.

COMMITTEE ON EQUAL OPPORTUNITIES IN SCIENCE AND TECHNOLOGY

Question: The Committee on Equal Opportunities in Science and Technology (CEOST), established by PL 96-516, has been in existence for six years and has published several comprehensive reports concerning the status of women, minorities, and the handicapped in science and engineering professions. How has CEOST contributed to the achievement of NSF's major goals in research and education?

Answer: The Committee on Equal Opportunities in Science and Technology (CEOST) plays a very valuable role in helping NSF achieve its goals in research and education as follows:

1. Provides a forum where issues that address enhancing the participation of underrepresented groups in science and engineering are discussed.

2. Serves as a resource for the identification of qualified individuals for advisory groups and rotational staff members.

3. Suggests activities that would increase the pool of scientists from the underrepresented groups in all NSF activities.

4. Assesses overall management plans that address the problem of increasing the representation of the targeted groups in all NSF activities.

5. Serves to review and monitor NSF programs aimed at increasing the number of persons from underrepresented groups in the science and engineering talent pool. An example is the "mainstreaming" of targeted programs such as Research Opportunities for Women and Minority Research Initiation to ascertain that they continue to serve as

exemplary mechanisms for entry capable and potentially productive scientists into NSF research programs.

6. Continues to assess the composition of NSF advisory groups and enhance the awareness of program officers in including minorities, women and handicapped scientist and engineers in future selections for membership.

7. Provides guidelines for data collection that help NSF monitor progress in meeting its goals of increasing representation of minorities, women and handicapped persons in all its activities.

Question: Which of its recommendations have you adopted?

Answer: CEOST recommendations that have been adopted by NSF include:

1. Increases in the numbers of minorities, women and handicapped as members of NSF advisory groups.

2. Seminar on demographic trends and the scientific and engineering workforce that was held March 24, 1986. This was found to be interesting, informative, and beneficial to NSF staff in attendance.

3. A report to the Director (and subsequently a presentation to the Education and Human Resources Committee of the National Science Board) concerning the need to reestablish the Resource Centers in Science and Engineering (RCSE) that were previously funded through the SEE Directorate.

4. Development of public announcements of accessible NSF facilities for the physically handicapped.

5. An extension of two years to those MRI AND ROW awardees who have done outstanding work during the first three years of their grants.

6. Provided guidelines that helped NSF program officers in "tracking" and by assisting in the revision of the form that monitors characteristics (such as gender and ethnicity) of recipients of NSF awards.

7. Changes to the Science Education and Engineering Directorate proposal guidelines to provide greater emphasis on the special needs of minorities, women and the handicapped in precollege science education.

Question: In what ways could CEOST increase its effectiveness?

Answer: The effectiveness of CEOST could be increased in the following ways:

1. Other science agencies could use NSF's Committee as a model for the establishment of similar bodies which could then work together to develop comprehensive strategies to increase the participation of minorities, women and handicapped in science and engineering.

2. Increased interaction with the Office of Science and Technology Policy and the Office of Technology Assessment would increase the awareness of the special needs of minorities, women, and the handicapped in science and engineering and lead to the development of coordinated strategies for dealing with them.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ROBERT STAFFORD

(Reauthorization of the National Science Foundation, March 26, 1986)

Question: To what extent has the NSF coordinated its Math-Science programs with those at the Department of Education. Specifically, what strengths does the Foundation bring to Science Education that would benefit the Department's activities?

Answer: While NSF's resources for science education are significantly less than those of the Department of Education the NSF Science and Engineering Education Directorate is well informed about the programs of the Department. For the most part, Foundation programs are designed to provide leadership in areas not supported directly by the Department. In those cases where there is overlap, cooperation between the two organizations has been good in recent years. For example, SEE's Division of Materials Development, Research and Informal Science Education and the Department have jointly funded large projects e.g., the programming of the TV series 3-2-1 Contact.

In the area of Studies and Analyses there is close cooperation with the Center for Statistics in the support of surveys of mathematics and science and testing of student achievement. SEE and the Center have jointly supported longitudinal surveys of teacher characteristics, innovative testing procedures for measuring higher order thinking skills of students of science and mathematics, international surveys of science achievement, and studies of teacher supply, demand and qualifications. The SEE Program Director for Studies and Analysis serves on advisory panels established by the Center to design longitudinal surveys and other studies, as well as serving on contract evaluation panels and as a reviewer of reports of survey findings to be published by the Department of Education.

In the area of teacher preparation and enhancement, SEE staff and the Department maintain regular and direct personal contact for information flow, in order to plan complementary activities. The Department, for example, has helped to distribute to each school district in the country a Directory of NSF-Supported Teacher Enhancement activities. The goal is to facilitate teacher awareness of these opportunities and to encourage school districts and states to use some of their Title II funds to help support teacher attendance and the in-service activities with their peers, both of which are part of many of these projects. This seems to be a good way to combine support from the Department of Education's block grant program (mandated through formula) with the projects, selected on the basis of peer review and scientific quality, that NSF supports.

It should be remembered, however, that the Department and NSF have an entirely different approach. NSF's focus is on providing leadership and exerting leverage. NSF does have a number of particular strengths that might benefit the Department as it moves to improve its math-science programs. First, NSF has the extensive experience and access to scientists, engineers, and educators that the Department may not have. NSF also has a programmatic reputation that emphasizes excellence in the projects supported. Thus through contacts with the Department, NSF is making available different aspects of our programmatic experiences to help the Department in its precollege science and mathematics programs.

Question: The Foundation's budget request includes support for its experimental program to stimulate competitive research. This program is designed to assist certain states in improving their academic research capabilities and thus compete more successfully for Federal R&D support. (Vermont is currently participating in the current planning phase of the program). What other activities does the Foundation plan to undertake or expand that would help broaden participation of under-represented groups in its research programs.

Answer: The Foundation supports other activities that are designed to broaden the participation of under-represented groups in its research programs. These include:

- An increased emphasis in undergraduate research and education to help build an improved undergraduate environment and stimulate students to consider careers and graduate work in the sciences and engineering;
- Minority Research Initiation, which supports research by scientists and engineers who are members of minority groups under-represented in science careers and who have not previously received Federal research support;
- Research Improvement in Minority Institutions, which is designed to enhance the research and training capability of predominantly minority institutions through research and equipment awards;
- Minority Research Centers of Excellence, a new program proposed for FY 1987, which will support the establishment of a limited number of centers to help increase the population of minority scientists and engineers by assisting them to develop research capabilities and interests across all levels of education;
- Research Opportunities for Women, which supports research by women who have not received previous Federal support as principal investigators or whose careers have been interrupted, to help them develop as individual researchers;
- Visiting Professorships for Women, which is

designed to increase the support and recognition of women researchers so that they might serve as role models for women students and help to increase the participation of women in the science and technology enterprise; and

Small Business Innovation Research, which supports research by small businesses, amounting to 1.25 percent of the Foundation's total research obligations.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR EDWARD KENNEDY

NSF BUDGET REQUEST

Question: Mr. Bloch, your budget requests a total of $1,685.7 million in new budget authority for FY 87. This represents an increase of almost $200 million over your current level. The Senate Budget Committee has recommended for NSF an increase of $100 million in outlays above the FY 86 post Gramm-Rudman level. However, this committee will be reporting an authorization bill that will be providing NSF with new budget authority. Historically, what has been the relationship of outlays to new budget authority within the research programs in the NSF? On average, how much new obligational authority is outlaid from this account in the fiscal year for which it is appropriated?

Answer: There are slight variations between programs and from year to year. However, our current estimate is that approximately 55 percent of new obligational authority is outlaid in the year in which it is appropriated.

Question: Please quantify for the committee what amount of new budget authority should be provided over the FY 86 Gramm-Rudman freeze level if this committee's authorization bill for FY 87 is to be in compliance with the senate budget committee's resolution?

Answer: Based on our experience, in order to outlay an increase of $100 million over the post Gramm-Rudman level, an addition of about $200 million in budget authority would be required.

BASIC RESEARCH AND ECONOMIC COMPETITIVENESS

Question; Mr. Bloch, your budget presentation stresses the importance of basic research and its link with economic competitiveness. Are you satisfied with the total federal investment in basic research? Are the mission agencies, including the Defense Department, recognizing and supporting basic research at a level sufficient to meet national needs?

Answer: I have made the point in my statements to the committee that it is my personal opinion basic research in the U. S. is underfunded. During the last few years, despite the fact that substantial increases in basic research have occurred, defense R&D has been increasing at a faster rate and therefore reducing the basic research percentage from what it was a few years ago. The President's budget that is now before the Congress continues to provide strong support for basic research, however, I believe that a more fundamental reexamination of the allocation between support for basic research, applied research and development is warranted.

WOMEN AND MINORITIES

Question: In taking the FY 86 Gramm-Rudman reductions, you chose through normal reprogramming procedures, to protect the Women and Minority programs within the Foundation. You are to be commended for that decision. This committee has been a consistent supporter of those programs. What initiatives are you proposing in FY 87 with respect to Activities that would broaden the participation of women and minorities in the NSF research activities?

Answer: We are proposing a new initiative, Minority Research Centers of Excellence (MRCE), at $4,000,000. MRCE is designed to help predominantly minority institutions to plan and implement programs to upgrade their scientific and engineering research and training capabilities, and to provide assistance to neighboring minority institutions for this purpose. The goal is to increase the number and quality of minority scientists and engineers engaged in research careers.

We propose an increase of $200,000 (from $2,500,000 to $2,700,000) for Minority Research Initiation (MRI). MRI seeks to bring minority scientists and engineers who have not previously received Federal research support into the mainstream of NSF research funding.

We propose an increase of $250,000 (from $2,200,000 to $2,450,000) for Research Opportunities for Women (ROW). ROW is directed to the needs of women scientists and engineers who have not received previous Federal research support and seeks to help them enter the main stream of NSF research funding.

SUPERCOMPUTING

Question: Would you outline for the committee the long range plans for the supercomputing initiative?

Answer: The NSF plans to expand the development of scientific applications of supercomputers; to increase training for scientists in the use of advanced computational techniques; and to stimulate the most innovative parts of the U.S. computer industry.

Thus far, NSF has established a network of national supercomputer centers, four of which are now operational (San Diego, Illinois, Cornell and the Von Neumann Center in Princeton, NJ), and a fifth (Pittsburgh) which will become operational in June of this year.

The response from the research community has been strong. We expect these centers to provide adequate supercomputer services for the U. S. academic community until mid 1987. At that point, we project the demand for access to these machines will exceed the supply. Our long range plan is, if budget levels allow, to increase the capacity of the NSF supercomputer centers by upgrading the machines at existing centers, by establishing new national centers, and by exploring the use of the emerging generation of new machines. Our studies of the research needs suggest that eventually as many as 10 - 12 centers may be required, and that new technology may fill additional needs.

NSF will also encourage the development of new technology solutions to scientific computing needs. This will be accomplished through the support of projects to generate more algorithms and software, and to develop alternative technology for more cost effective solutions to problems.

Question: What is the Status of your networking activities?

Answer: The national scientific research network, known as NSFnet, which has been in the planning stage for the past year, is becoming a reality through the implementation of: (1) direct communication links between the supercomputer centers and their consortium members, (2) "backbone" links between the supercomputer centers, and (3) regional networks which will connect many institutions to the NSFnet backbone. We expect that more than 50 institutions will become part of the NSFnet during the next year.

Concurrently, with the establishment of NSFnet, we will be taking advantage of various community networks which already provide service to academic research scientists. These community networks include CSNET and BITNET. Also, we have recently concluded an agreement with the Defense Advanced Research Projects Agency to expand and augment the well-known ARPANET to provide access for 30 to 40 institutions.

The response to the supercomputing and networking activity has convinced us that these tools are critical to the leadership and productivity of the U. S. research and industrial communities. We have taken small but very important steps toward what is really needed.

ENGINEERING

Question: NSF has just announced the establishment of five new Engineering Research Centers. Please comment on the effect this new program has had thus far on the ways our academic institutions approach fundamental engineering research?

Answer: The ERC program seeks fundamental changes in the ways academic engineering institutions approach both engineering research and education. It is clear when programs seek cultural changes in any segment of the community a great deal of patience is required because changes are gradual and take some time to be fully understood and implemented.

All of the first six centers have implemented activities leading toward change. Very briefly these activities include:

(1) Plans have been made in each center to develop undergraduate course materials relating to the thrust of the center. Some of the new courses being developed will be "team taught" by several disciplines. In addition, many ERC's have begun to involve undergraduates in the research.

(2) Industrial advisory committees have been formed to develop significant dialogues between industry and university researchers in order to clearly understand current and projected industrial research needs. Several centers will have industrial members on the campus and participating in the research. The focus of the centers on fundamental engineering research should assist the dialogue because of the non-proprietary nature of such research.

(3) All the centers have research participants from several different disciplines. The objective is to stimulate new approaches and insights to solution of problems that might not come from individual disciplines.

(4) The topics of each center are broad enough to encourage both students and faculty to develop a systems approach to the engineering topic under consideration.

Thus, mechanisms are in place at the Centers which have the prospect of changing the ways engineering schools approach fundamental engineering research and education. The Engineering Directorate will continue to monitor and assess these changes in order to be assured that progress is being made.

BIOTECHNOLOGY

Question: What plans do you have to expand the Foundation's support for basic research in Biotechnology?

Answer: NSF obligated $81.5 million in FY 1985 and expects to obligate $86.6 million in FY 1986 for research related to biotechnology across the Directorates for Engineering, Mathematical and Physical Sciences, and Biological, Behavioral and Social Sciences. The Chemistry of Life Processes initiative and the Engineering Research Center devoted to biotechnology process engineering are examples of major NSF activities begun in that year.

The FY 1987 Budget Request includes an increment of $20 million for expanded activities across the three directorates. Three approaches characterize the expanded emphasis:

- Large Centers: Two to four centers for multidisciplinary research related to biotechnology will be established. These centers are to receive awards to modify and equip multidisciplinary biotechnology laboratories. They will take advantage, so far as possible, of the investments already made by industry, academe and state governments in research facilities and would provide support for the establishment of unique specialty centers. The awards are to support the long-term operation of these sophisticated facilities. An example of such a facility would be a neuropeptide microchemistry facility for the analysis of protein sequences, coupled with the capability to produce synthetic peptides and synthetic genes. Such a center would involve the participation of analytical chemists, biochemists, neurobiologists, neurochemists and molecular biologists.

- Mini- or Departmental Centers: These awards, numbering up to 10, will support smaller cross-disciplinary groups and individual departments by providing unique facilities and instrumentation. In some problem-oriented areas, such as bioreactor design, stability of engineered proteins and cell adhesion, these awards would be a combination of instrument and research support. In most cases, these "minicenter" awards will be directed toward the provision of unique and expensive multiuser instrumentation required for contemporary work in molecular biology and biochemistry.

- Cross-disciplinary Research and Training: The remaining funds will be directed toward the expansion of cross disciplinary research and training programs in engineering, the ecological sciences, plant sciences, molecular biology and chemistry. The training of personnel in multiple aspects of biotechnology-related activities has been a central focus of the NSF program for the past several years, and it remains a high priority.

APPOINTMENT OF ASSISTANT DIRECTORS

Question: Last year, we discussed whether or not it was necessary for the Foundation's Assistant Directors to be appointed by the President and confirmed by the Senate. At that time, Mr. Bloch, you felt that it was unnecessary. Do you still believe that to be so?

Answer: With the Senate's confirmation of Dr. William Merrell to be the Assistant Director for Astronomical, Atmospheric, Earth, and Ocean Sciences last year, the Foundation is for the first time in over two years fully staffed in terms of assistant directors. These are the Foundation's most senior management officials. I believe that for an agency to function effectively, it must have a full complement of its senior level managers on board at all times. When a vacancy does occur in these positions, prudent management dictates that a qualified candidate must be identified and quickly installed.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR CLAIBORNE PELL

Question: Last year the Congress provided the Foundation with the authority to permanently indemnify the ocean drilling contractor. I understand that a consortium of oceanographic institutions, including Woods Hole and the University of Rhode Island, is managing the ocean drilling program for the Foundation. Is that authority still necessary and what is the general status of the Ocean Drilling Program?

Answer: The Foundation contracts with Joint Oceanographic Institutions, Inc. (JOI) for the management of the Ocean Drilling Program. JOI is a not-for-profit corporation comprised of ten major U.S. oceanographic institutions, including Woods Hole and the University of Rhode Island. Texas A&M University chartered and converted the drillship JOIDES RESOLUTION for scientific ocean drilling. The ship is owned by Overseas Drilling Limited, which is a jointly owned subsidiary of British Petroleum, Ltd. and SEDCO, Inc.

In carrying out any offshore drilling program, commercial or scientific, there are certain inherent risks which are referred to as "drilling peculiar risks." Liabilities for which indemnification is required most commonly arise from the potential for:

1. Damage to underground reservoirs;
2. Pollution, contamination to, degradation of, or other damage to the environment caused by blowout, loss of well control, or seepage of underground fluids;
3. Costs of control of blowout or wild well;
4. Costs of drilling one or more relief wells:
5. Loss of property or life while in the process of drilling.

In commercial oil industry practice, the hiring company, typically a single oil company or joint venture group, is responsible for risks peculiar to drilling. It is the hiring company that selects the location for drilling, performs the necessary predrilling surveys, selects the depth of the hole and specifies the operations to be conducted in the process of drilling and coring the hole. It is the hiring company which stands to profit if oil or gas is found. The offshore drilling company provides only a service at a specified cost. The hole itself is the responsibility of the hiring company; and the hiring company must, therefore, accept the risk of unavoidable mishaps.

Offshore drilling contractors are required to provide insurance coverage for workers compensation, employee's liability, comprehensive general liability, hull insurance, and basic coverage for minor seepage, pollution, and well control. Industry standards call for approximately $10 million of liability with up to a maximum of $50 million of "drilling peculiar risk" for riser drilling. The hiring company provides indemnification beyond these limits.

Although the risk from scientific drilling is substantially less than oil field drilling, offshore drilling contractors are not able to "risk the company" on the remote possibility of a "drilling peculiar" accident. The existing NSF contract requires the ODP drilling contractor to carry $200 million of coverage for riserless drilling and $500 million for riser drilling. The NSF is providing $1.012 million for the insurance premiums through the JOI contract in 1986. This level of coverage is a factor of 4 to 10 greater than industry standards and provides a very low risk that the government will be called upon for indemnification.

The Ocean Drilling Program has completed its first year of operation. The scientific and operational results have been excellent. Research topics included carbonate reef studies off the Bahamas, continental margin structure off Western Europe, high latitude studies of the Norwegian Sea and Baffin Bay, tectonics and structure of the Mediterranean Sea, and volcanic and hydrothermal studies on the Mid-Atlantic ridge. Technological developments include new systems for sampling volcanic terrain, improved drilling and sampling tools, and hole reentry techniques.

International members at present are Japan, Canada, France, Federal Republic of Germany, and the United Kingdom. The European Science Foundation representing a consortium of ten smaller Western European countries is planning to join in 1986.

Question: As you know I have long been interested in the health and vitality of our nation's museums. Art and history museums have been able to apply to the Arts and Humanities Endowments for program support but science museums have not enjoyed such easy access to government funding. Since we talked about this issue at last year's hearing, has the NSF undertaken any fresh initiatives in this area?

Answer: SEE support for museum activities continues to have high priority and steady growth as part of a coherent balance between large scale mass-media projects and direct hands-on experience in museums and clubs. We are proud that much of the current innovation in science museums -- such as traveling exhibits, museum consortia and museum "camp-ins" by Girl Scouts and Boy Scouts -- is directly related to our past and present leadership and support.

The broad outline of the Informal Science Education Program which provides support for a range of museum activities has not changed for the past year. However, our ability to respond positively to requests for support of worthwhile projects has increased. In FY 1985 we awarded $7,198,291 in response to proposals; the current plan for FY 1986 calls for awards totaling $8,500,000.

Grants to museums in FY 1985 include:

1) A grant of $1,140,000 for three years to Impression Five Museum, Lansing, Michigan for "Development of Traveling, Prototype Exhibits."

2) A grant of $207,000 for two years to the Boston Museum of Science for the development of "Curriculum Materials for Traveling Exhibits."

3) A grant of $340,017 for two years to the Association of Science-Technology Centers for the development of "Traveling Exhibits in Mathematics, Engineering, and Paleontology."

4) A grant of $579,968 for three years to the Milwaukee Public Museum for the development of a "Permanent Interactive Exhibit on the Tropical Rain Forest."

5) A grant of $437,300 for three years to the San Francisco Exploratorium for "The Development of a Series of Exhibits Concerning Cellular and Molecular Biology."

6) A grant of $182,000 for two years to the Children's Museum of Boston for the development of "Guessing, Estimating, and Counting: A Traveling Exhibition."

7) A grant of $49,434 for one year to the Florida State Museum for development of "A Slice of Life: Earth History to Touch -- A Traveling Exhibition."

8) A grant of $16,266 for one year to the Mississippi Museum of Natural Science for "Museum Activities Coordinated with 3-2-1 Contact."

In addition to the efforts made through the Science and Engineering Education Directorate, the Foundation supports the systematic collecting and maintenance of anthropological material through grants to museums and universities. Awards made by the Anthropology Program of the Biological, Behavioral, and Social Science Directorate during FY 1985 include the following:

1) A grant of $60,349 for 12 months to the Field Museum of Natural History for "Improving Accessibility and Conditions for Preservation of the Human Skeletal Collection."

2) A grant of $84,055 for 12 months to Columbia University for "Conservation and Storage of Andean and Manhattan Archaeological Collections."

3) A grant of $150,000 for 24 months to the University of Pennsylvania for "Collections Management Project, 1985-87."

4) A grant of $45,500 for 15 months to the University of Utah

for "Conservation, Inventory, and Management of the Great Basin Collections."

5) A grant of $40,114 for 18 months to Southwest Museum for "Southwest Museum Basketry Renovation Project."

6) A grant of $35,983 for 12 months to the Museum of New Mexico for "Basketry Storage Project."

7) A grant of $75,703 for 12 months to the University of Pennsylvania for "Establishment of a Repository for Fossil Hominid and Primate Molds and Patterns."

8) A grant of $40,706 for 24 months to the University of New Mexico for "Cataloging and Conservation of a Systematic Southwestern Skeletal Collection."

9) A grant of $37,500 for 12 months to the Illinois State Museum for "Curation of the Comparative Archaeozoological Collection."

10) A grant of $9,983 for 6 months to the Neville Public Museum for "Storage of Ethnology and Wisconsin Archaeology Collections."

11) A grant of $62,468 for 18 months to the School of American Research for "Conservation of Southwestern Indian Textiles."

12) A grant of $5,894 to the University of California-Davis for "Renovation of the C. Hart Merriam Ethnographic Collection" (Supplement).

13) A grant of $39,076 for 12 months to Auburn University for "Cataloguing and Documenting the Historic Creek Archaeological Collection of the Alabama Department of Archives and History."

14) A grant of $61,090 for 24 months to the Murray State University for "Systematic Management of the Wickliffe Mounds Archaeological Collection."

Finally, the Division of Biotic Systems and Resources makes grants to museums to support basic research conducted by museum biologists. Approximately $4 million has been invested in such grants during each of the past four years; no large change is anticipated for the future. The number of awards per year has decreased from 46 in FY 1983 to 29 in FY 1985, primarily because the funding policy in this program has moved toward single grants that fund research for several years instead of grants that provide only one year of funding.

Question: Under current guidelines, what must a science museum specifically do to receive support for the Foundation?

Answer: To receive Foundation support through the Informal Science Education Program, a museum must first submit a preliminary proposal (usually a few pages is sufficient) in which the goals and procedures of the proposed project are outlined. If these match our program objectives the proposer is encouraged to submit a formal proposal as described in the Program Announcement (NSF 85-9) and the NSF document "Grants for Scientific and Engineering Research (NSF 83-57). Recently the program held a very successful workshop, together with the Association of Science and Technology Centers, to help museums understand the process of developing and articulating good proposals.

BBS programs do not require a formal preliminary proposal before submitting a fully developed proposal as specified in "Grants for Scientific and Engineering Research." However, BBS does suggest that museums make contact with the appropriate program officials before submitting a proposal to ensure that all relevant factors will be covered.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR PAUL SIMON

We're currently seeing an inadequate supply of young people entering science and engineering fields. Because young people must elect certain courses in high school and in college for such careers;

Question: What is NSF doing to interest young people in science and technology during pre-collegiate years? What are the formal and informal programs involved, especially enrichment programs through institutions such as museums, planetariums, and the media?

Answer: A large fraction of the awards made by the Division of Materials Development, Research, and Informal Science Education are designed to improve the science education received by students in the elementary and secondary schools. This is true of all grants awarded by the Instructional Materials Development Program (awards totaled $5,982,122 in FY 1985) and the Research in Teaching and Learning Program (awards totaled $1,999,313 in FY 1985).

The Division also manages the Applications of Advanced Technologies Program (awards totaled $7,545,697 in FY 1985). Projects here focus on research and development of technologies that have the potential to improve the efficiency and effectiveness of precollege science education; project results undoubtedly impact education at all levels.

The Informal Science Education Program (awards totaled $7,198,291 in FY 1985) provides support for television and radio programming, the development of exhibits for museums, zoos, and planetaria, and educational activities offered through groups such as Girl Scouts and 4H Clubs. The consumers of these products are not only precollege children, but older students and adults, as well.

A particularly successful example of such effort is our leadership and funding of daily television series about science and mathematics for young children. The science series is viewed regularly by a significant percentage of all children (currently over 20%) and we are hopeful that the new mathematics program will have similar impact. In addition, we are now providing support to a TV series ("Reading Rainbow") that encourages children to read books about science.

Question: What is the NSF plan to bring pre-collegiate program support up to levels that will "prime the pump" for undergraduate and graduate programs in the sciences?

Answer: The Directorate for Science and Engineering Education has instituted several strategies to "prime the pump." In the area of teacher enhancement we support projects that provide continuing professional development for about 10,000 K-12 teachers each year. Many of these projects involve leadership teachers and a teacher-of-teachers model in which the leader teachers provide in-service professional development for their colleagues. By this multiplier device, NSF support can affect about 50,000 teachers each year. This is about 3.5% of the 1.4 million elementary and secondary (science and mathematics) teachers that are the program's targets. Over a 5-year period at the present level of funding, (the equivalent of $18 million for FY 1986) and assuming that the leaders continue to exert their influence, about 25% of the target audience will have been reached, these teachers enriched and up-dated in content and methods of science instruction, and their classrooms more effective "pump primers."

Further to increase the number of young people choosing careers in science and engineering, the NSF is especially encouraging and supporting projects designed to increase the numbers of women and minority students prepared for and choosing these careers. These choices are often determined long before college or even high school. Efforts in teacher enhancement projects seek to increase the awareness of teachers to methods that will be effective in instructing and encouraging women, minority, and handicapped students to pursue science and mathematics courses and interests from the earliest years. Special efforts are made to fund such projects.

In the teacher preparation area, the NSF is making a special effort to solicit and support projects dealing with the preparation of middle school science and mathematics teachers. Few programs exist for preparing teachers to teach students at this critical age when many career decisions are being formulated and hardened. The intent is to invest between $6 and $10 million in several exemplary programs that combine the best science and science education resources of an institution with practitioners and school systems to produce excellent middle school science and mathematics instruction. Increased support for teacher preparation can widen the numbers of examples supported and increase the scope of targeted support to other grade levels and preparation of teachers in subjects where critical shortages of teachers exist.

The activities of the Division of Materials Development, Research, and Informal Science Education help to improve the science education opportunities available to students during their primary and secondary school years. However, the program that most directly prepares students to enter college as science, mathematics, and engineering majors is the Instructional Materials Development Program which is designed to improve the quality of science education received by elementary and secondary school students. This program is currently budgeted to spend $8,500,000 in FY 1986; awards through this program totaled $5,982,122 in FY 1985.

As a rule, neither the schools nor the persons who design Foundation programs attempt to separate precollege students into the categories "college bound science majors" and "others." We believe, in fact, that all children of precollege age should receive science education of such a quality that the possibility of majoring in science is an option to every student that enters college.

There is substantial evidence and consensus that the major dropout from science takes place very early and is heavily conditioned by early experience, motivation and conceptual development. This is the reason for our substantial emphasis on early mathematics and science.

Question: Studies show that science and mathematics interest must be instilled in the early years (grade 3 through 8). Is there a program at NSF that addresses precollegiate science and math at an even earlier point than high school?

Answer: All SEE programs at the precollegiate level have, since FY 1985, been targeting about half their support for projects at the elementary through middle school level. The program solicitation in the Teacher Preparation program, for example, is designed to elicit and support several exemplary programs for preparation of middle school science and mathematics teachers; $6-10 million has been targeted for this objective over the next 3-5 years. In the Teacher Enhancement program, a substantial increase in proposals at the elementary and middle school level followed announcement of the intent to pay special attention to these levels and half the teacher participants in supported projects are elementary and middle school teachers.

Further, whenever unsolicited proposals fail to respond to needs at the elementary school level, the Foundation issues solicitations that target areas of identified need. For example, two solicitations were issued by the Materials Development Program early in FY 1986 seeking proposals targeted on elementary school mathematics instruction and elementary school science materials. The science solicitation has special significance because of its emphasis on broad utility to typical teachers, students and schools. Because of this emphasis, we are stressing involvement and partnerships with publishers and other parts of the private sector. We believe that this will help to provide a valuable "real-world" sophistication and a long term consistency.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR JOHN KERRY

Question: It has been suggested that the Director of NSF should double as the President's science adviser. Do you favor this arrangement?

Answer: I discussed this at the recent House Appropriations Committee hearing and took the stand that I am not in favor of combining the positions of Director of NSF with the President's science adviser for the following reasons:

a. Both are more than full time positions. From my own experience, I certainly can say that about the Director of the National Science Foundation and, from working very closely over the last two years with Dr. Keyworth, I know firsthand of his schedule and activities.

b. There is a potential conflict inherent in combining these positions. The Director of NSF needs to be parochial at times and put the well-being of the Foundation ahead of everything else. The science adviser has to take an evenhanded approach within the scope of many agencies and departments that have a mission in science and engineering research and development.

Question: Do you believe that it is harmful to have a vacancy in the position of Presidential science adviser, and if so, have you communicated your concerns to the White House?

Answer: It has now been five months since Dr. Keyworth left the post of Science Advisor to the President, and I personally regret that the position has not been filled. I have expressed my view on this to the White House Personnel Office repeatedly, and to others who have a close relationship with the White House. Unfortunately, I don't see any movement in the direction of filling this important position.

Question: Has anyone in the White house contacted you concerning your recommendations for a replacement for Dr. Keyworth as Presidential science adviser?

Answer: No one from the White House has contacted me with regard to recommendations for a replacement for Dr. Keyworth. I have however, made my candidates known directly and indirectly.

Question: What, in your opinion, has been the impact of the Strategic Defense Initiative on academic research in science and technology?

Answer: It is too early to see what the impact of the SDI on academic research will be. However, I have had a number of conversations with Dr. James Ionson who head's SDI's office of Innovative Science and Technology. I have invited him to co-fund activities with the National Science Foundation in areas of common interest such as mathematics, software research, computer research, optics, atomic physics, and materials science. The Foundation would be willing to essentially "loan" the NSF peer review to SDI. I believe that this joint arrangement would yield a high-quality research program that would be braod inscope and generally beneficial to the Nation.

This would also signal to the academic community the interest of SDI in furthering basic research and basic understanding. We would hope that our active participation would guarantee the merit and openness of the research.

Question: Do you believe that the balance has tipped too far in the direction of military R&D, and away form civilian research in basic science in the U. S.?

Answer: I have made the point in my statements to the committee that it is my personal opinion that basic research in the U. S. is underfunded. During the last few years, despite the fact that substantial increases in basic research have occurred, defense R&D has been increasing at a faster rate and therefore reducing the basic research percentage from what it was a few years ago. The President's budget that is now before the Congress continues to provide strong support for basic research, however, I believe a more fundamental reexamination of the allocation between basic research, applied research, and development is warranted.

Question: If so, what can we do to correct this imbalance?

Answer: I have repeatedly urged that development areas of the federal R&D budget be reduced and those funds reallocated to basic research.

Question: Some $31.5 million in funding for pre-collegiate science education remained unexpended by NSF at the end of FY 1984. Why has NSF spent so little in the past few years on science education, in relation to funds appropriated?

Answer: SEE expenditures for precollege education are best explained within the context of the Directorate's changing status over the last five years. At the beginning of FY 1982 all then existing SEE activities were terminated with the exception of the Graduate Fellowships Program. In FY 1983 the Congress appropriated $15 million for the initiation of precollege level activities in addition to $15 million for Graduate Fellowships. However, a provision requiring Congressional approval prior to any expenditures delayed the call for and receipt of proposals until mid-year. This requirement allowed the Directorate to obligate only a small portion of the funds and $13.9 million was carried over to FY 1984.

The FY 1984 appropriation for precollege programs was $68.6 million. (This included $55 million in new appropriations, plus the $13.9 million carryover.) SEE made tremendous progress in hiring new staff, developing new programmatic activities and reestablishing contacts and credibility in the science education community and expended $37.1 million. The remaining $31.5 million was carried over to FY 1985.

At the beginning of FY 1985, while staffing and programs had progressed, it was still necessary to defer $31.5 million of the $113.5 million in appropriations to FY 1986. SEE did obligate all of the remaining funds which totaled $81.5 million, including the $50.5 million allocated to the two precollege divisions.

For FY 1986 we expect to obligate our entire budget of $84.7 million.

Question: What do you plan to do to increase NSF activities in the area of pre-college science education?

Answer: The FY 1987 budget estimate for precollege education programs in SEE calls for no increases above the FY 1986 level. In areas of specific need, program solicitations are used to focus the attention of the science and science education community and to support enough exemplary projects to provide choices and alternatives to ameliorate the need.

Question: Do you believe that the U. S. is falling behind the Soviet Union in the area of science education?

Answer: The answer to this question is based on preliminary results of a US/USSR comparative study by SRI International under a grant from SEE. Evidence suggests that Soviet students who have completed the required 10-year primary/secondary education (now representing some 96 percent of the 17-year-old population) have received a more extensive preparation in science and mathematics than has the majority of their U.S. counterparts. About 35 percent of total instructional time in the mandatory primary/secondary school program is devoted to mathematics and science in the USSR. An average of 6 hours a week of mathematics instruction and 6 to 10 hours a week of science instruction is required during each of the last four years of the secondary program. In comparison, only 46 percent of U.S. high school graduates (which represent about 72 percent of the 18-year-olds) have studied three or more years of mathematics and 30 percent have studied three or more years of science. While no comparative measurements currently exist to assess the level of achievement/competency of advanced college bound students in the U.S. relative to similarly advanced Soviet students--nor even relative to the "average" Soviet secondary school graduate--the amount of exposure to science and mathematics among the school-age population as a whole is considerably higher for the Soviet Union than is the case in the United States. In the USSR, mathematics is introduced at grade 1, biology at grade 5, physics at grade 6, and chemistry at grade 7. A number of different science subjects are studied concurrently during several grades as opposed to the usual U.S. practice in which exposure to different fields is confined to separate one-year programs. There are also 2 to 4 hours per week allotted for elective courses in grades 7 through 10, in which students may take subjects of their choice ranging from arts and humanities to special offerings in science and mathematics, such as advanced physics or chemistry and operational calculus (or remedial courses, when necessary).

The entire school population is exposed to the intensive science/mathematics oriented curriculum in the Soviet Union, rather than only that portion of students who elect to pursue such studies as is generally the case at the upper secondary level in the United States. This represents one of the most significant differences between the U.S. and U.S.S.R. educational systems. The Soviet educational structure is essentially designed to provide educated persons to the labor pool for the national economy. To meet those requirements, the U.S.S.R. has established a nation-wide educational structure, with standardized curricula, designated textbooks, and common examination procedures throughout the country. There is a uniform program of secondary education through grade 8, followed by a choice of channels to complete secondary education.

To put the above in some perspective relative to the situation in the United States, the following statistics are illuminating. Data from the National Center for Education Statistics (NCES) indicate that only about 72 percent of the 18-year-old population in the United States has completed a high school education. NCES has also estimated that of U.S. high school graduates in 1982, only 46 percent studied three or more years of mathematics and only 30 percent studied three or more years of science. In mathematics, only 7 percent studied trigonometry, 6 percent studied calculus, and 13 percent studied other advanced mathematics. In the sciences, only 24 percent studied chemistry, and 11 percent studied physics.

Comparative analysis of science and mathematics training in the United States and the Soviet Union should not rest on quantitative measures alone. It is important to note, for example, that evidence presented in the Soviet literature suggests that the quality of instruction is not uniformly good. For instance, there appears to be a wide disparity in urban as opposed to rural schools and in the Russian as opposed to the non-Russian republics. In addition, Soviet schools still have problems with facilities, particularly laboratories and computers. While computer literacy has been set forth as a major goal, computer education plans call for two distinct curricula for teaching computer skills: one for schools with computers and another for those with only mock-up/practice key boards. Actual plans call for clusters of computers in only 200 secondary schools.

In addition, it should be noted that by the early 1980s Soviet educators and officials themselves had become highly critical of their formerly much-acclaimed (by Western analysts at least) mathematics and science curricula in producing the level of achievement desired, and revisions and reforms have been instituted in the past several years. The nature of these revisions and their likely impact on science and mathematics education in the Soviet Union has not yet been thoroughly studied and evaluated. It is unclear to what extent such changes were politically motivated as opposed to educationally based.

Despite the need for further study and assessment, the strong orientation of the Soviet educational system toward science and mathematics is clear, as is the Soviet commitment to increase the knowledge and skills of the general population in such disciplines--a commitment only further attested to by the flexibility and willingness of Soviet educational specialists and government officials to institute revisions and reforms where perceived as necessary.

ADDITIONAL STATEMENTS

Dr. David A. Hamburg, Chairman, American Association for the Advancement of Science

Dr. George C. Pimentel, President, American Chemical Society

Dr. Leonard D. Goodstein, Executive Officer, American Psychological Association

Dr. Peter Farnham, Public Affairs Officer, American Society of Biological Chemists

Dr. Robert M. Rosenweig, President, Association of American Universities

Dr. David Jenness, Executive Director, Consortium of Social Science Associations

Engineering Education Task Force of the National Society of Professional Engineers, the American Society for Engineering Education, and the National Association of State Universities and Land-Grant Colleges

Federation of Behavioral, Psychological and Cognitive Sciences

Mr. Jon W. Fuller, President, Great Lake Colleges Association

Joint Policy Board for Mathematics

Society of American Archaeology

Statement by

Dr. David A. Hamburg

Chairman

American Association for the Advancement of Science

on

The Fiscal Year 1987 National Science Foundation

Budget Authorization Request

Submitted to

Committee on Labor and Human Resources

U.S. Senate

March 26, 1986

Mr. Chairman and Members of the Committee:

INTRODUCTION

On behalf of the AAAS, I would like to thank you for the opportunity of submitting a statement for your consideration. I do appreciate the privilege. And I think, in general, that there is a wonderful kind of permeable membrane between the scientific and engineering communities and the policy world in this country that may well be distinctive. It is an opportunity that we do not take lightly. Foreign colleagues often marvel at the openness of such forums as this and at the access enjoyed by U.S. scientists and engineers to those of you in the political world to express our views. We hope the interchange is mutually beneficial.

Although I am President of the Carnegie Corporation of New York, I am presenting this statement in my capacity as Chairman of the Board of Directors of the AAAS. Briefly, we are an umbrella-like organization whose members span virtually all fields of science and engineering; affiliated with us are some 285 other scientific, engineering, technical and professional organizations with a total membership in the range of five million.

Within the past decade or so, we have become more and more involved in matters of national science and technology policy and the public understanding of science and technology through our publications, various special conferences, hearings such as this, and our annual meeting. This growing interest in national policy matters is, of course, indicated in the depth of our support for this Committee's work. Also, we have recently revised the format of our flagship publication, Science, to reflect a greater emphasis on science policy areas.

ORGANIZATION OF STATEMENT

I would like to cover several major topics briefly based on our preliminary analysis of the President's FY 1987 Budget as submitted to the Congress. In the context of these major topics I will comment on specific aspects of the FY 1987 National Science Foundation Budget Request. I intend to address the following topics:

- Policy Environment for Science and Technology
- Overview of R&D: Federal and National -- Including the Arrival of Gramm-Rudman-Hollings
- International Science and Technology
- Infrastructure Issues: Facilities, Equipment and Instrumentation
- Management of Science and Technology

In concluding, I will offer several suggestions and recommendations for the Committee's consideraton.

POLICY ENVIRONMENT FOR SCIENCE AND TECHNOLOGY

Politicians, Scientists and Engineers Share a Tremendous Responsibility for Nurturing a Favorable Environment for Science and Technology in the United States

About a decade ago, I attended an event which left a lasting impression on me. At the 1976 Nobel ceremonies in Stockholm, Americans made a clean sweep of the prizes in all fields, an unprecedented event. Was this some special birthday gift of the various Nobel committees to celebrate our bicentennial? Hardly! At the ceremony of Nobel prize presentations, Sune Bergstrom, the great Swedish biochemist who is Chairman of the Board of the Nobel Foundation, observed that the really interesting question was not that the Americans won all the prizes in

1976, but how was it that Americans had won about half of the prizes during the preceding 25 years. In his remarkable opening address, he went on to point out some of the reasons he saw for the preeminence of American scientists:

- The recognition that basic science can have powerful practical consequences
- Generous immigration policies which permitted many outstanding scientists from Europe and elsewhere to come to the United States
- Recognition of the importance of science and technology for economic progress
- The intellectual stimulation and fostering of innovation made possible by political freedom and open communication
- The strong national commitment to support of basic science through institutions such as the National Science Foundation and the National Institutes of Health
- The democratic atmosphere of American universities and their laboratories -- in contrast with the hierarchial, authoritarian structures prevailing in many other countries
- Special attention to the fostering of research by talented and dedicated young people

While I am sure that others could be added, Bergstrom's set is a very important array of conditions for the flourishing of American science and technology and their effective use in society that we need to keep in mind, especially at a time of budgetary pressures such as the present.

Stating this another way, I would offer the following basic point: We must consider research and development as an investment in the future — near-term and long-run. It is important to bear this in mind not just for "high tech" industry; it is just as important to see increased commitment to research and development over a wide range of industries. And it may well be that the principal hope of the so-called "smoke-stack" industries will come through increased emphasis on R&D.

We must understand that an expenditure for research and development is not just another expenditure, equivalent to, say, the purchase of office supplies. An expanding array of economic evidence supports the investment character of R&D in providing the basis for economic growth and improved human well-being.

Such a concept is increasingly acknowledged by our own private sector in this country and by other countries around the world. Indeed, it seems to me there is a strong political consensus here, held by individuals from all parts of the political spectrum, about the validity of R&D as an investment. While I acknowledge the real problems facing you — and all of us — in dealing with deficit reduction, I contend that a sustained and robust national effort in research and development is fundamental to a strategy of economic and social growth as well as to improving the quality of life.

Some Brief Reflections on National Science and Technology Policy and Contributions of Science and Technology

American science and technology, as suggested by Bergstrom, have earned great respect throughout the world. In fields such as health, agriculture, space, communications, and computers, the world's respect for American science-and-engineering based achievement borders on awe.

Despite past achievements, perhaps the question might be raised, "In a 'bottom-line' sense, during a time of economic stringency such as the present, what difference would it make if we cut back for a time on our national commitment to science and technology to save money and reduce the responsibility of the Federal Government?" I would respond by saying, "While there are some things we could do which might be more foolish, there are not many." Why is this so?

Through most of our history as a people, our economic success was in substantial part predicated on an open-minded, pragmatic orientation to technological utilization of natural resources for the general well-being. Much of this was based on a common sense approach to imaginative craftmanship, as exemplified by many of our great inventors. But even by the Civil War, President Lincoln recognized that we would have to orient more toward fundamental research as a way of generating technological innovation.

Thus, over time, increasingly the new technologies central to economic progress and national defense — national security in a broad sense -- came to depend upon advances in fundamental science as we invested in the future during the past half century.

Science and science-based technologies have become a pervasive part of human experience in the 20th century and the key to present and future well-being. Science is not a separate activity, remote from the lives of people -- however arcane it may seem to be. To the contrary, it is really bound up with everything we do which is central to modern living and much of its promise for the future, not only in a material sense but also in relation to social justice.

If we are seriously concerned with economic growth, productivity, innovation and equitable distribution of the resulting benefits, as we should be, then we must also be seriously concerned with the vigor of our scientific enterprise for we are really talking about the future of society. From this enterprise comes an increasing array of opportunities in every facet of human experience. Our food supply, our health, our global environment, our security, and our ability to make a living, to improve the quality of life and diminish human suffering — all depend increasingly on science-based activities.

AN OVERVIEW OF FEDERAL AND NATIONAL RESEARCH AND DEVELOPMENT LEVELS

In this section I will discuss briefly several important features and possible trends involving national and Federal R&D, with special emphasis on the arrival of Gramm-Rudman-Hollings. Also, I will comment on the overall character of the NSF Budget Request for FY 1987.

The National Total for Research and Development in 1985 Reached Nearly $109 Billion — Exceeding Over $100 Billion for the First Time

It is estimated that the total amount invested in research and development in the United States in 1985 will be in the range of $108.8 billion. The Federal total comes in at about $51.7 billion (or 47 percent), while the non-Federal component is estimated at $57.1 billion (or 53 percent). As Appendix 1 shows, the ratio has been essentially constant since 1980.

Appendix 1 also shows that total national R&D for 1986 is estimated to in the vicinity of $118.6 billion. Another important point is that after a long plateau of little real growth since the the mid-1960's, substantial growth began in the late 1970's (as shown in the constant dollar column).

It is also clear from an examination of the Appendix and other supporting data that the private sector is making significant investment in research and development as part of its various competitive strategies. The major focus is on applied and development activities in contrast to basic research.

The Arrival of Gramm-Rudman-Hollings Has So Far Had Mixed Effects on the Aggregate Levels of Federal R&D: A Reduction in FY 86 Was Made But the President Has Submitted the FY 87 Budget with Substantial Increases

While the overall Federal budget clearly shows the influence of G-R-H, and the FY 86 R&D total ended up at about $2.54 billion lower than the appropriated amounts, the overall FY 87 research and development level seems to be remarkably healthy. There are, however, various "symptoms" which seem to call for closer examination. For example, I would like to review with you the little table below which shows a comparison of aggregate numbers for Federal research and development, beginning with FY 1984. (The figures are for appropriations, i.e.,budget authority).

Total Federal Research and Development
(in billions of dollars)

	FY 84 Approp.	FY 85 Approp.	FY 86 Approp.	FY 86 G-R-H Impact	FY 87 Request
Total Fed R&D	$46.0	$51.7	$57.5	$54.7	$63.2
(Basic Research)	($7.1)	($7.8)	($8.3)	($8.0)	($8.6)
Basic Res. Percent	15.4%	15.1%	14.5%	14.7%	13.6%
Total Federal R&D Divided Between Defense and Non-defense					
National Defense	$30.5	$34.7	$39.6	$37.6	$46.4
Non-defense	15.5	17.0	17.9	17.1	16.8
Defense Percent of Total R&D	66.3%	72.0%	68.9%	68.8%	73.4%

A quick look at these numbers shows that the total amount for Federal R&D has been increasing at a healthy clip. However, the numbers also vividly underscore NSF Director Bloch's statement to you last week that the already small share of dollars allocated to basic research is steadily dropping, even though NSF's budget fared well in a difficult budget period. I draw this latter trend to your attention in relation to my earlier comments about how important it is, very frankly, that the basic research programs of the Federal Government be protected in the coming budgetary battles. And the National Science Foundation's programs are squarely in the middle of the strongest candidates for such protection and nurturing. Any cutbacks in the basic research area by the Federal Government will not be picked up by the private sector -- as we have testified many times before, based on extensive review of the types of R&D that industry does support.

A more detailed look at the entire budget -- although I will not review specific numbers today — shows that its dominant feature is the overwhelming emphasis on national security research and development. Since 1980, this element has risen from about 50 percent of Federal R&D to over 73 percent in the FY 1987 budget request, and may well be on a rising trend. Other important themes in the overall budget appear to be as follows:

o Overall, the National Science Foundation was one of the few civlian agencies which received a healthy increase, 8.4 percent. The increases were largely in the physical sciences, engineering, biotechnology, and advanced computational capabilities — much of which was couched in terms of improving our industrial competitiveness. Space was another area singled out for increases — although the shuttle disaster has raised considerable uncertainty about NASA's ultimate budget configuration.

o There is a leveling off of resources allocated to agricultural, energy and environmental research and development — as well for the Agency for International Development, the Veterans Administration and various other smaller agencies.

o Reductions are the order of the day for the Departments of Transportation, Interior, and Commerce, and the National Institutes of Health, although the last word may not yet be in place on these cuts.

These trends or themes do not seem to be results of G-R-H influences; rather they reflect the continuation of Administration policies in place for the past five years. Some of the reductions may well support deficit reduction objectives, but it would not appear as though this was the primary motivation, this year.

Future Effects of G-R-H Deficit Reduction Pressures Are Likely to Be Significant for R&D

However, as we attempt to peer ahead -- along with you -- it seems reasonable to forecast that the deficit reduction trend -- with or without G-R-H in whatever form it emerges from the Supreme Court review — is likely to remain a potent political force. Among the resulting effects it is quite possible that further pressures will be placed on so-called discretionary areas such as civilian R&D. Just as likely, we would guess that national defense R&D will be subject to the same kind of pressures.

In short, in the outyears of 1988-1991 it is quite conceivable that we might experience a drastic paring down of our national R&D capabilities -- including levels of research, production of scientists and engineers, and modernization of our research facilities, equipment and instrumentation.

Numerous concerns arise from this scenario; included is the basic problem of how we can preserve crucial elements of our scientific and technological enterprise and avoid foregoing or delaying follow-through on important opportunities. Finally, as I discussed earlier, there is the vital task of maintaining and investing in — for the long pull -- a healthy basic research establishment, even if it becomes necessary to cut back on other parts of research and development.

The particularly distinctive responsibility of the Federal Government is in basic research. In the AAAS effort to keep in touch with corporate research and, of course, with the foundation world, which is my own personal responsibility, it is clear that both the profit and non-profit private sector has only a modest contribution to make to basic research. So it is a matter of profound significance that we maintain the base on which we build the rest of our technical achievements and the application of those achievements.

While I am sure you will be presented with many examples of deficit reduction impacts, I think it is important to identify a problem which otherwise might be lost in the "noise level." First, I acknowledge that this is not your legislative concern; however, changes being discussed in postal rate policies could lead to substantial cost increases for distribution of scientific and technical journals -- the lifeblood of scientific communication. It is feared that such changes, if they come to pass, could have a chilling effect on many precariously financed journals, particularly in smaller or emerging fields.

Effects of G-R-H on Higher Education Will be Severe: Since Science, Math and Engineering Education are Integral Parts of Our Scientific and Technological Enterprise in the U.S., There Are Reasons to be Concerned

Although Dr. Rosenzweig will address education extensively in his testimony, we feel strongly about putting AAAS views on record. The FY 1987 budget for higher education, at $6.7 billion is 23 percent below the FY 1986 amount of $8.7 billion. And while the various programs deal with a broad variety of purposes, science, math and engineering education will be among the fields hit hard by the reductions. I will come back later to several specific comments on NSF's program and its education plans.

We have been coming before you regularly with our concerns about science, math and engineering education. Despite progress on a number of fronts, the looming impacts of G-R-H are reasons for serious alarm. The litany of problems has been well-documented in report after report and study after study, in recent years.

- There is very little science instruction in elementary schools.
- At the secondary levels too many students are unchallenged; there is a grave and worsenihg shortage of well qualified science and mathematics teachers; the curriculum lacks coherence and needs overhauling; and computer literacy is a major concern.

- At the present time, undergraduate science and math education receives almost no support.

- There is a low level of research effort on teaching and learning; resources are limited for the development of classroom materials; teacher training in mathematics and science throughout the precollege level is woefully inadequate.

During the past few years the nation has experienced a rediscovery of education, especially in the linkage between science and technology education and the economy. Much is happening at state and local levels under the influence of forward-looking governors and local officials, but it would be a grave mistake to use such actions as the basis for the Federal Government to step aside from its own special responsibilities. Too much is at stake. It is a tremendous challenge; and the Federal Government must be an active participant and leader in finding ways to link the "science-rich" sectors (the universities, corporate labs and national labs) with the "science-poor" sectors in the elementary and secondary schools.

We may be at an historic moment in education with a challenge and opportunity comparable to the period of the Civil War when the land-grant colleges were established. Historically, education support has always been tied to other objectives, such as national security (Sputnik) or social justice (Great Society). Now, the emerging tie is to the scientific and technological needs of the new economy. With this emergence comes the urgent need to raise the status of education as a profession.

In thinking about the basic education issues, I think these are among the more important questions:

- How can we give all our children, regardless of social background, a good opportunity to participate in the modern technical world?

- What constitutes a decent minimum of literacy in science and technology that should be a part of everyone's educational heritage?

- Given the rapidity of socio-technical change, how can we make lifelong learning a reality so that people can adjust their knowledge and skill to technological change?

- Since educational institutions will more than ever be preparing people for unpredictable circumstances, how can they prepare for change itself?

- How can we broaden the spectrum of the sciences to include the full range of life sciences and behavioral sciences so that modern education will become increasingly informative with respect to human experience?

- How can the educational system foster a scientific attitude useful both in problem solving throughout society and in relating scientific principles to the major issues on which an informed citizenry must decide?

- How can we achieve an informed world-wide perspective in an era of profound global interdependence?

Such questions and the need to undertake systematic inquiry into them are founded in our strong belief that a fundamental transformation of our society and our economy is occurring as a result of the pervasive influences of science and technology. We believe there is the need for widespread and deep educational improvement to cope with accelerating change and that the current momentum — particularly in the states — suggests a readiness for action.

This set of problems is far too complex to be dealt with using simplistic nostrums such as "education is a local problem in our system of government." Of course, local control of education is at the core of our system; no serious-minded person even questions this premise. And, yes, far larger proportions of the total cost of education are borne at state and local levels but Federal money, experimental programs, and research activities provide highly leveraged capabilities that are difficult or inefficient to replicate at state levels. The massive, complex effort required in science education calls for national attention, stimulation, and leadership. The National Science Foundation is a good place to exercise this leadership but we also think the Executive Office of the President could and should play an important role.

The challenge is to develop and carry out an effective mix of Federal, state and local educational activities to cope with the transformation I described a moment ago. I'm reminded of an old anecdote of H.L. Mencken's; he said: "For every complex problem, there is always a simple answer -- and it is always wrong." We need to work at meeting the real challenge.

NSF Budget Request in Science and Engineering Education is Something of a Disappointment: There is Too Little Progress, Too Slowly

Given the overall favorable treatment for the NSF budget, and the knowledge that Director Bloch, as well as the National Science Board, are serious in their intentions to improve the NSF's Science and Engineering Education program, we are reluctant to come down too hard in appraising the education budget and what lies behind it.

Nevertheless, we have concluded that, taking into account the importance of the overall national educational challenge discussed above, it is necessary to observe that there has been too little progress, too slowly accomplished. It is little short of astonishing to realize that a study to prepare a long-range plan, authorized and directed by the Congress in 1984 is just now getting underway with a target completion date of eighteen months from now.

Surely, it is not a matter of a shortage of reports and studies; I have already mentioned the plethora of such activities, including the excellent work of the National Science Board itself. We do hope the Subcommittee will exercise its oversight role in following the new study closely. In the meantime, we would like to offer several suggestions for the evolution of a national education program, largely under the auspices of the NSF:

o There should be a balanced program of support for science, mathematics and enginering education. Our system requires strengthening from the bottom to the top, i.e. from the precollege level, through undergraduate to graduate to post-doctoral levels. The specific needs at each of the levels has been thoroughly documented.

o Support should be balanced with regard to the functional activities undertaken -- research on teaching and learning; development of supporting materials; use of informal, out of school, approaches based in a variety of places such as museums; and training of teachers who are qualified to provide sound instruction throughout the precollege level.

o A strategic plan must be developed which is based on a reasonable degree of stability and growth commensurate with the magnitude of the problems previously described. The kinds of funds required have already been partially identified in the Board's own Commission Report on Precollege Education in Mathematics, Science and Technology.

o Finally, it seems logical that the National Science Foundation should provide the management focus on a national program of the kind we are discussing.

INTERNATIONAL SCIENCE AND TECHNOLOGY

Investment in R&D is Growing Among Our International Partners and Competitors

In earlier appearances, I and other AAAS witnesses have repeatedly focused on the international dimension of science and technology, both in terms of the connection to international economic competitiveness and to international cooperation, particularly in science matters.

As a brief update, Appendices 2 and 3 to my statement show the allocation of national resources to investments in research and development by a number of key nations: France, West Germany, Japan, the United Kingdom and the USSR. As a summary point, each of the nations -- except the United Kingdom -- continues to allocate an increasing percentage of its Gross National Product to research and development — particularly in civilian-related areas.

Since I have in earlier appearances developed this line of thinking, I will only observe today that nothing has changed: the intensity of the international economic competitive environment is directly related to national investment in science and technology. A salient point is that our own national investment in civilian R&D has essentially leveled off while the Japanese ratio continues to increase (Appendix 3).

The AAAS Applauds and Strongly Supports Current Studies by the National Science Board and the Foundation Itself in Exploring Ways the NSF Might Serve the National Interest Through its Activities in International Science and Engineering

In supporting the Science Board's Committee on International Science, the AAAS endorses enthusiastically a recommendation of the Committee that the NSF assume a leadership role in planning and implementing one or more major global initiatives, in which other U.S. and foreign organizations could participate. For example, through our Consortium of Affiliates for International Programs we have been consulting widely with others in the scientific and engineering community to develop a list of five to ten candidate global initiative programs. From such a list it is hoped that a suitable activity or activities might be mounted.

A potential candidate has been identified in a special National Academy of Sciences Report as an "International Geosphere-Biosphere Program (IGBP)" which might be conducted under the auspices of the International Council of Scientific Unions (ICSU). While it would seem appropriate for the NSF to have a leading role, an IGBP should be truly international, for the concerns are those of the entire planet. Considerations of access alone would require the participation of scientists and technicians from both advanced and developing countries representing all parts of the world. Proposed study areas would include:

- The recovery of the past history of environmental change

- Changes in the current physical environment
- Global changes in the biosphere
- Global biogeochemical cycles
- The global hydrologic cycle

It is encouraging that the NSF budget includes increased emphasis on the global geosciences through a series of interrelated research efforts treating the earth as an integrated system of physical, chemical, and biological processes — as reported to you by NSF Director Bloch. However, while other U.S. agencies were mentioned as participating, there was no indication that the initiative was "international" in the sense called for by the IGBP concept.

We think close attention should be given to this dimension of the emerging geosciences activities at the NSF. More important, we hope that this Committee will carefully consider how best to use its influence and prestige for bringing the IGBP into being: it could be an achievement of unparalleled importance in the history of human cooperation.

New Perspectives Are Required on Developing Coherent Strategies for Carrying Out International Cooperation — Including 'Big Science'

Here I must acknowledge and agree with a set of remarks presented by House Science and Technology Committee Chairman Don Fuqua at a "Technology Development" Conference in Bonn, West Germany, late in 1984. His thoughtful and provocative comments have probably not received the attention they deserved. His proposition that international cooperation in science and technology must be given greater priority is sound, and I agree wholeheartedly with his statement that the "time has come for it also to become a routine international exercise among nations."

In getting down to the really "hard stuff," Mr. Fuqua goes past the conventional rhetoric that international cooperation is a great goal; he raises some past "unthinkables" — such as the necesity of giving up on a degree of nationalism in exchange for real collaboration on projects and research facilities, especially those connected with 'big science.' There is no doubt whatsoever in my mind that no nation will be able to afford "going it alone" in building the coming generations of major facilities and projects of a global nature such as the IGBP discussed earlier.

INFRASTRUCTURE ISSUES

The Research Facilities Problem Remains Critical at Universities: Aging Deteriorating, and Terribly Out of Date

Much has been said to you in the past and I am aware of your concerns, so I will not dwell on this sad story today. I would only say that things are just as bad and getting worse. For the record, we would like to note our strong support for H.R. 2823, "The University Research Facilities Revitalization Act of 1985," and hope there will be some forward movement this year.

Even if the G-R-H climate does not permit the allocation of any additional amounts of money this year, it would be quite valuable for the problem to be examined thoroughly and a plan of action devised for such time as when funds might become available. We understand that an NSF report based on last July's meeting at the National Academy of Sciences will be available soon.

The Prospects for Progress in Coping with Research Equipment and Instrumentation Problems Seem Brighter Than Those for Facilities

We strongly support the actions taken by Mr. Bloch in increasing the total NSF allocation for instrumentation and equipment from $223 million in FY 1986 to $260 million in FY 1987. We agree with him that modern research requires state-of-the-art instrumentation and equipment. While the overall requirement remains huge -- in the billions -- the FY 87 decision certainly represents some modest progress. We especially appreciate the modest increase for the undergraduate equipment program; we must not forget the entire range of education as I discussed earlier.

MANAGEMENT OF RESEARCH AND DEVELOPMENT ISSUES

There are several areas of concern and questions related to the management of Federal research and development programs which we would like to put on the table. Among these are peer review, indirect costs and the balance of research grants between individual investigators and centers.

There is Growing Controversy About the Manner in Which An Increasing Number of Large Research Grants and Facilities Bypass Peer Review or Even Regular Congressional Review Procedures

There is not time today to discuss our concerns in any detail; however, the trends are sufficiently disturbing to warrant bringing up the subject. The concept of peer review of science is a central characteristic of the American system and it is generally acknowledged that this approach accounts for much of the strength of American science. It is with dismay that many of us observe what seems to be increasing attempts -- many of them successful -- to bypass regular peer review processes during the budget allocation proceedings in Congress, or even the Committee-review system itself. Two recent examples illustrate the point I am making:

o In the hectic atmosphere surrounding the windup of its 1985 Session, Congress "earmarked" special research grants for ten universities in the Defense Department's R&D program. The Conference Report on H.J. Resolution 465 — the continuing appropriations for FY 1986 — included the ten grants, none of which had been through even the Congressional committee review system. By the end of January, only one university, Cornell, had turned down its $10 million allotment of the total $65.5 million package. Ironically, Cornell had applied through normal Defense channels and had not sought the special political assistance given to it, much to its credit.

o A package of amendments to the Higher Education Act (H.R. 3700) contained an array of specially "earmarked" facility authorizations for a number of universities. Regrettably, an amendment to substitute the "earmarking" with a method of distributing such funds competitively was defeated.

It is not that we lack understanding or appreciation of the geographical distribution question for R&D grants, contracts and facilities; my entire statement for you today rests on the premise of the close connection between advances in science and technology with economic and social growth. Moreover, we are fully sympathetic with the near sense of desperation about aging or absent research facilities at many universities, and the desire to stimulate economic development.

But if we, in a time of increasing budget pressures, begin to rush down the path of allocating science resources based largely on "political clout" for individual institutions or grantees, then surely we are at the beginning of undermining faith in our peer review system. This is not a matter of protecting the "haves" of the scientific world; it strikes at the vitality and strength of American science.

Our urgent request to the Committee is that this general topic be placed on your oversight agenda. Your forum can provide an effective place and set of circumstances for addressing these issues, as you have in the past. Achieving a workable set of policies which takes into account the various competing interests would be a major accomplishment.

Reports of OMB Intentions to Impose Uniform Caps on Indirect Costs of Federally-Assisted Research Grants Call for Caution

Again, this is a topic which could tie us up in discussion for days. Indeed, there are not many subjects which have been around longer in the world of Federal support for research and development. But without going into the specifics I would only wish to state the concern of the AAAS that such moves not be taken without timely notice, discussion and adequate transition periods. There are many complexities and contending interests in this area, not only between universities and the Federal Government but also within universities themselves.

ADDITIONAL NSF BUDGET COMMENTS

While I have discussed previously several aspects of the FY 1987 NSF Budget Request, there are a few more specific comments to offer:

o Overall, the budget is a good one, considering the times.

o I would like to acknowledge the NSF's — and particularly Director Bloch's -- role in the continuing attention and progress on programs for encouraging and supporting scientific and engineering study and careers for women, the disabled and minorities. As an NSF report released at the end of January shows, there have been substantial gains in science and engineering employment for women and minorities since the mid-1970's.

Given this success, which can be attributed in part to NSF's pioneering role, we would urge a continuing focus for such areas as:

(1) Being cautious about ill advised or premature mainstreaming of minority-focused programs.

(2) Providing support for minority research centers.

(3) Building a cadre of minority, women and disabled students in science and engineering by early involvement in research; it is possible that this might be encouraged by riders to research grants.

(4) Special training for various NSF program officers as the minority-women-disabled programs become mainstreamed.

o We remain somewhat puzzled by the status of the social and behavioral sciences research. For example, even in such important topics as industrial productivity and innovation, research findings from the social and behavioral sciences frequently are of greater consequence than those from the physical sciences and engineering. We regret that OMB and the NSF do not seem to share this point of view.

We remain concerned about the marginal attention given to the behavioral and social sciences. For example, no special or distinctive statement regarding these vital fields is made in the NSF Budget Summary for FY 1987. I focus on this because these sciences are just beginning to recover from the budgetary beating they took a few years ago.

They are crucial to understanding serious problems in our changing economy, its relation to technological advances, and its demands on education for a transforming workforce. Another crucial problem is conflict resolution in a world full of prejudice, hatred, and violence. Moreover, the past decade has seen a sea change in awareness of the links between health and behavior -- e.g., smoking, alcohol abuse, a variety of damaging drugs, and several major risk factors for heart disease, stroke and cancer.

These three areas of great concern -- the economy, conflict resolution, and health-behavior links -- all illustrate the importance of the behavioral sciences for our future well-being.

o I am pleased that this Committee chose to respond favorably to the many concerns expressed last year about the little program on Ethics and Values in Science and Technology (EVIST). It is also encouraging that Director Bloch has decided to continue sponsoring research in this field. Having said this, I have a small cautionary note: as small programs get distributed throughout the array of NSF directorates and programs, there is the very real risk of a loss of focus. We hope the Subcommittee will continue to monitor this important little area where so many important interdisciplinary studies are done.

CONCLUDING REMARKS

o First, the overall picture of American science and technology is one of apparent health; we invest large amounts of money in R&D. But these amounts must be looked at in comparison to our own needs, the size of our economy and the relative investments by competitors in defense and civilian related areas. There are ample reasons for caution in cutting back or restraining too severely R&D growth, in the G-R-H environment.

o In the realm of basic research, particularly, there is reason for alarm. It is no overstatement to suggest that the American scientific eminence to which Bergstrom referred in his Nobel address is in some danger of eroding.

o The specific budget of the NSF for FY 1987 warrants your strong support. But beyond this budget and this year, and despite the looming

G-R-H pressures, I would argue for some slowing down of large, development programs if that becomes necessary to maintain healthy, steady but modest building of the great research-sponsoring agencies of the Federal Government such as the NSF, the National Institutes of Health, and, yes, the Defense Department.

o In making judgments on such support, science policy should place special emphasis on basic research across the entire spectrum of the sciences; it is from such research that the companies and industries of the 21st Century will arise. In this context, we must foster the continuing interplay of basic and applied sciences so that each may stimulate the other. Special attention must also be devoted to creating and encouraging an environment for cooperation among government laboratories, universities, and industry.

o We strongly support the Administration's drive to provide incentives for industry to strengthen research and development across the board, not only in the obviously high-tech industries. Building a bipartisan consensus for support in this area is a high priority.

o Strengthening basic research in the field of agriculture is important to our well-being, our health, and our role in the world. Our big problem here is that we have done so well that complacency can become a danger. (Indeed, the same could be said for health research.) But there are issues that deserve our sustained attention: massive soil erosion, looming water shortages and contamination, decrease in the genetic variability of plant life, and the uncertain role of the new biotechnologies with regard to agriculture.

o The oil glut is temporary. The basic facts have not changed. The long-run supply is seriously limited and many of the sources are politically volatile. We cannot set aside research on conservation and alternative energy sources. We must take a long view of the fact that the United States is the most energy-intensive nation in the world today and that others are moving rapidly in this direction.

o We must undertake and support a variety of measures, including stronger support for education, to provide distinctive opportunities for young people to participate effectively in this emerging scientific and technological age. These opportunities should be available regardless of race, gender, or religion.

o Finally, and this is nothing new to this Committee, it is increasingly important that eventually we face the need for better governmental and private mechanisms in science policy formulation: we must do a better job of analyzing and appraising the various options and policy measures embedded in just the short list of issues I have reviewed -- and it is by no means complete. This general need becomes even more acute as we contemplate the growing international and global dimensions which I have discussed only briefly in my statement.

MAJOR RECOMMENDATIONS

1. Provide strong support for the NSF Budget as proposed. While our differences with the NSF on education are significant, they do not translate into specific budget comments this year. We would hope that the Committee will use its good offices to speed up the planning process at NSF. For the longer term, a growing role for the NSF in science education will be crucial.

2. Focus attention on the newly emerging dimensions of international science and technology -- ranging from a more pronounced role for the NSF to the considerations for establishing one or more major global cooperative efforts. The International Geosphere-Biosphere Program (IGBP) seems to be a likely candidate.

3. Give special attention in international science and technology to more intensive examination of more effective ways to collaborate on research projects and facilities.

4. Carefully monitor the NSF commitment to the behavioral and social sciences.

5. Consider an up-dated oversight examination of peer review, particularly in light of several trends discussed briefly in my statement.

6. Consider a number of the policy issues noted above -- particularly that dealing with new institutional ways to accomplish the required policy analysis more effectively.

7. Finally, in the turbulent times ahead as you deal with the political ramifications of deficit reduction, please consider the investment character of research and development -- particularly, basic research.

APPENDIX 1

Trends in Federal and non-Federal R&D outlays: 1953 and 1960-86
[Percents]

Year	Federal				Non-Federal	Total National (Constant) Dollars (1982)	Total National (Current) Dollars
	Total	Defense Related	Space Related	Civilian Related			
1953	54	48	1	5	46	$ 19,744	$ 5,124
1960	65	52	3	9	35	43,648	13,523
1961	65	50	6	9	35	45,764	14,316
1962	64	48	7	9	36	48,176	15,394
1963	66	41	14	11	34	52,585	17,059
1964	66	37	19	9	34	57,202	18,854
1965	65	33	21	11	35	59,351	20,044
1966	64	33	19	12	36	62,589	21,846
1967	62	35	14	13	38	64,406	23,146
1968	61	35	13	13	39	65,458	24,605
1969	58	34	11	13	42	64,672	25,631
1970	57	33	10	14	43	62,405	26,134
1971	56	32	9	15	44	60,385	26,676
1972	56	32	9	15	44	61,414	28,477
1973	53	30	8	15	47	62,427	30,718
1974	51	27	8	16	49	61,467	32,864
1975	51	26	8	17	49	59,885	35,213
1976	51	26	8	17	49	62,134	39,018
1977	50	25	8	17	50	63,653	42,783
1978	50	24	7	19	50	66,769	48,129
1979	49	23	7	19	51	70,077	54,933
1980	47	22	7	18	53	73,235	62,593
1981	46	23	7	16	54	76,610	71,840
1982	46	25	7	14	54	79,328	79,328
1983 est.	47	27	7	13	53	83,862	87,178
1984 est.	47	29	6	12	53	89,937	97,275
1985 est.	47	30	6	11	53	97,283	108,800
1986 est.	47	30	7	10	53	$102,504	$118,600

NOTE: Detail may not add to 100 percent because of rounding.
SOURCE: National Science Foundation

APPENDIX 2

National Expenditures for Performance of R&D as Percent of Gross National Product (GNP) by Country: 1961-86

YEAR	FRANCE	WEST GERMANY	JAPAN	UNITED KINGDOM	UNITED STATES	U.S.S.R.
1961	1.37	NA	1.39	2.47	2.68	NA
1962	1.47	1.25	1.47	NA	2.68	2.64
1963	1.55	1.41	1.44	NA	2.81	2.80
1964	1.81	1.57	1.48	2.30	2.90	2.87
1965	2.00	1.72	1.52	NA	2.84	2.85
1966	2.07	1.81	1.46	2.32	2.83	2.88
1967	2.12	1.96	1.52	2.30	2.84	2.91
1968	2.08	1.98	1.60	2.26	2.76	NA
1969	1.93	1.82	1.64	2.27	2.66	3.03
1970	1.92	2.06	1.85	NA	2.57	3.28
1971	1.90	2.18	1.85	NA	2.42	3.46
1972	1.90	2.20	1.86	2.11	2.40	3.71
1973	1.77	2.09	1.90	NA	2.26	3.81
1974	1.79	2.13	1.97	NA	2.23	3.74
1975	1.80	2.22	1.96	2.19	2.20	3.78
1976	1.78	2.15	1.95	NA	2.19	3.61
1977	1.76	2.14	1.93	NA	2.15	3.54
1978	1.76	2.24	2.00	2.24	2.14	3.54
1979	1.81	2.40	2.09	NA	2.19	3.59
1980	1.84	2.42	2.22	NA	2.29	3.76
1981	2.01	2.49	2.38	2.41	2.35	3.75
1982	2.10	2.58	2.47	NA	2.51	3.68
1983	2.15	2.52	2.61	2.24	2.56	3.82
1984 prel.	2.24	2.52	2.60	NA	2.58	3.95
1985 est.	2.27	2.61	NA	NA	2.72	NA
1986 est.	NA	NA	NA	NA	2.76	NA

SOURCE: National Science Foundation, Organization for Economic Cooperation and national country sources.

APPENDIX 3

Estimated Ratio of Civilian R&D Expenditures[1] to Gross National Product (GNP) for Selected Countries: 1967-85

YEAR	FRANCE	WEST GERMANY	JAPAN	UNITED KINGDOM	UNITED STATES
1967	NA	NA	1.51	NA	1.88
1968	NA	1.80	1.59	NA	1.83
1969	NA	1.87	1.63	NA	1.79
1970	NA	2.01	1.79	NA	1.76
1971	1.5	2.0	1.8	NA	1.6
1972	1.5	2.1	1.8	1.5	1.6
1973	1.4	2.0	1.9	NA	1.6
1974	1.4	2.0	2.0	NA	1.6
1975	1.5	2.1	1.9	1.4	1.6
1976	1.4	2.0	1.9	NA	1.6
1977	1.4	2.0	1.9	NA	1.6
1978	1.4	2.1	2.0	1.5	1.6
1979	1.4	2.3	2.1	NA	1.7
1980	1.4	2.3	2.2	NA	1.8
1981	1.5	2.4	2.4	1.7	1.8
1982	1.6	2.5	2.5	NA	1.9
1983	1.7	2.4	2.6	1.6	1.9
1984 est.	1.8	2.4	2.6	NA	1.8
1985 est.	NA	2.5	NA	NA	1.9

[1] National R&D expenditures, excluding government funds for defense.

N/A = Not available.

SOURCES: National Science Foundation and Organization for Economic Cooperation and Development.

American Chemical Society

OFFICE OF THE
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George C. Pimentel
President-Elect, 1985
President, 1986
Immediate Past President, 1987

March 24, 1986

The Honorable Orrin G. Hatch
Chairman
Committee on Labor and Human Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

As the world's largest scientific society dedicated to a single discipline, the American Chemical Society offers the following observations on the Administration's budget request for the National Science Foundation for FY 1987. These comments will focus primarily on research in the chemical sciences.

The NSF Organic Act directs the Foundation to initiate and support basic research and education programs at all levels. The Foundation's importance to the scientific research and education enterprise in the U.S. is beyond dispute. NSF bears the major responsibility for maintaining the health of basic scientific research in the U.S. It accounts for about 28 percent of federal support for basic research in academic institutions and maintains U.S. scientific strength by funding research in all fields of science and engineering. It is in the best interest of the country for Congress to fund the NSF at least at the level proposed by the Administration for FY 1987. Under this proposal, support for Research and Related Activities would increase from the FY 1986 Gramm-Rudman-Hollings figure of $1,294.1 million to a total of $1,479.0 million in FY 1987, representing an increase of $184.9 million or 14.3 percent.

While many features unite the various scientific disciplines, these disciplines differ in their organizational patterns and in their top-priority research needs. For example, in high energy physics, an accelerator may hold the key to progress; in astronomy, a large telescope may be central to future advancement. Progress in chemistry today arises from a significant number of small but well-equipped laboratories.

What happens in these laboratories is very important to societal needs and for the economic competitiveness of this Nation. Due to its nature, chemistry inherently makes contributions to our national progress that are most impressive. Our entire physical world is made of material that lends itself to preservation, substitution, and transformation. These activities are carried out through chemical science and technology. Most scientific disciplines, ranging from molecular biology to astronomy, make use of chemistry. A large number of industries use chemistry in the manufacture of their products. The routine analytical sciences which support the nation's health systems use chemistry. Chemistry is truly a pervasive science.

The recently published National Academy of Sciences/National Research Council (NAS/NRC) Report, Opportunities in Chemistry, details how advances in the chemical sciences can be the key to future progress leading to new processes and materials, more energy and food, a cleaner environment, and better health for the citizens of the world. These advances are dependent upon ideas and experimental results emanating from basic research studies.

The support of the National Science Foundation is essential to the vitality of the research base residing in our academic institutions. In fiscal year 1984, NSF provided 47 percent of the federal obligations for basic research in chemistry performed by universities and colleges; most of this support was contributed by the NSF Chemistry Division.

The American Chemical Society endorses the recommendation of the NAS/NRC Report that states that the NSF Chemistry Division budget should be doubled over a three-year period. The Society likewise endorses the following emphases in the FY 1987 request for the NSF Chemistry Division:

- Initiation of a five-year plan in shared instrumentation to fund ongoing maintenance and operations support associated with new instruments, and increased allocations for dedicated instruments in FY 1987. The ACS, as well as the NAS/NRC Report, recommends that annual operating and maintenance costs be built into the NSF shared instrumentation program, and that funds for dedicated instruments be increased. In addition, there is an initiative in computational chemistry. The ACS supports this initiative which will effectively integrate use of computers by researchers.

- Support for collaborative research activities in materials chemistry, chemical catalysis, and development of new modern instruments, as well as collaborative and individual investigator projects in the chemical underpinnings of biotechnology. These research areas are among the fields of study which the Academy Report identified as providing opportunities for significant intellectual advancement that will also help yield social and economic returns for the United States.

- Increase of the average grant size in FY 1987 over the FY 1986 figure.

While the overall increase of 17.6 percent above the FY 1986 Gramm-Rudman-Hollings figure in the Chemistry Division's budget is healthy, it falls short of the 25 percent increase recommended in the Academy Report. Nevertheless, it is an important step in the right direction that must be preserved in the FY 1987 budget process, and maintained in future fiscal years. The ACS urges Congress to support this requested increase in chemistry, which is small when compared to the potential benefits to the economy and our society as a whole.

The ACS believes that as a nation we must insure that the human resources needed by our industries are well-trained and educated. The Foundation is the lead federal agency that attends to the overall health of the academic support structures that produce the Nation's scientific and engineering manpower. Without this continued NSF support, the Nation will be deferring the training of numbers of scientists and engineers who are critically needed by U.S. industry. Chemistry is an especially crucial area since chemists make up the bulk of physical scientists employed by U.S. businesses. Our other major comments on the NSF FY 1987 request focus on this support structure and are summarized as follows:

- The American Chemical Society notes that the Directorate for Science and Engineering Education will surely require a larger expenditure of funds in future years to accomplish its overall goals. The Foundation is to be commended for its programs in the K-12 areas; however, new programs are needed at the undergraduate level where future scientists and engineers receive their education.
- The Society is pleased that NSF is proceeding with a study of the need for new or renovated scientific facilities. The ACS supports a competitive, merit-based peer-review process. Such a process must be the primary mechanism for selection of proposals for large-scale research centers and facilities, as well as for the selection of proposals for research and instrumentation designated for them.
- There is broad recognition that continued productive communications between U.S. scientists and scientists in other countries are important to economic development. The ACS supports the FY 1987 budget request for International Activities, but regrets that the Foundation does not seem to have sufficient resources to add new cooperative research activities.
- The Foundation is to be applauded for its programs that enhance the participation of underrepresented groups or institutions in research activity and that improve the Nation's scientific and engineering infrastructure. The ACS is pleased that Presidential Young Investigators, Visiting Professorships for Women, Research Opportunities for Women, Support for Predominantly Undergraduate Institutions, Minority Research Initiation, and Research Improvement in Minority Institutions are among those programs with a continued funding commitment.

In conclusion, the ACS is heartened to see that the importance of basic chemical research and of education is stressed in the Foundation's budget request. The Society urges Congress to continue support for these areas at a time of fiscal restraint.

Sincerely yours,

George C. Pimentel

George C. Pimentel

cc: Other Members, Senate Committee on Labor
and Human Resources

American
Psychological
Association

STATEMENT OF

Leonard D. Goodstein, Ph.D.
Executive Officer
American Psychological Association

on behalf of

THE AMERICAN PSYCHOLOGICAL ASSOCIATION

before the

UNITED STATES SENATE
Committee on Labor and Human Resources

on the subject of
NATIONAL SCIENCE FOUNDATION AUTHORIZATION
Fiscal Year 1987

March 26, 1986

The Honorable Orrin G. Hatch, Chairman

1200 Seventeenth St. N.W.
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Mr. Chairman and Members of the Committee, I am Dr. Leonard D. Goodstein, Executive Officer of the American Psychological Association (APA). Thank you for this opportunity to submit our views on the authorization of the National Science Foundation for Fiscal Year 1987. APA represents the concerns of more than 76,000 psychologists, many of whom conduct important research with the support of NSF.

In this statement we will address specific areas of the proposed Fiscal Year 1987 NSF authorization of interest to behavioral and social scientists. We will then comment at some greater length on an area of great concern to this Committee, the Administration and concerned Americans: the revitalization of this nation's economic and technological base.

NSF FISCAL YEAR 1987 REAUTHORIZATION

APA appreciates this opportunity to strongly endorse the Administration's proposed Fiscal Year 1987 research budget for the National Science Foundation. We commend the President and NSF Director Erich Bloch for proposing that NSF's authorization be raised to $1.7 billion even in this time of the most urgent fiscal austerity. These increases have been proposed by the Administration because of its conviction that investing in basic scientific research will improve our competitiveness abroad and our scientific base at home. APA is in agreement with that assessment of the importance of basic scientific research and strongly supports the President's Fiscal 1987 budget request for NSF. We commend the Administration for proposing to increase funding for the Biological, Behavioral and Social Sciences (BBS) Directorate by 12.4 percent over projected Fiscal Year 1986 funding levels.

Increases of this magnitude are needed to restore vigor to behavioral and social science research programs at NSF; these programs are still lagging far behind historical levels of support. It is significant that support of behavioral and social science research has fallen from 6.1 percent of NSF's research budget in Fiscal Year 1980, to 4.1 percent in Fiscal Year 1985, and to 4.0 percent proposed for Fiscal Year 1987. Between Fiscal Years 1980 and 1987, in fact, NSF support for the behavioral and social sciences has actually decreased when measured in constant dollars.

To help restore the behavioral and social sciences to their 1980 levels of support at NSF, we urge the Committee to concur in the $3 million added to the Behavioral and Social Sciences Directorate in H.R. 4184, which was approved by the House Science, Research and Technology Subcommittee on March 18. These funds would be targetted specifically to behavioral science research in the Behavioral and Neural Sciences (BNS) division, and to regular research grants in the Social and Economic Sciences (SES) Division. It is these areas, behavioral science research and individual investigator-initiated research within the social and economic sciences, that have fared the worst between Fiscal Years 1980 and 1986. Fiscal Year 1986 funding for the BBS Directorate is projected at $247.5 million, some $6 million and 2 percent below Fiscal

Year 1985 levels. Some behavioral and social science programs within BBS, however, are expected to have their Fiscal Year 1986 budgets cut by 10 percent or more below Fiscal Year 1985.

SCIENCE AND ENGINEERING EDUCATION

APA urges the Committee to reiterate its support for the strengthening of science education activities at NSF. We share concerns expressed by Congress many times that improvement is needed in our nation's science education activities. For Fiscal Year 1987 the Administration has proposed that $89 million be authorized for the Science and Engineering Education (SEE) directorate at NSF. We are hopeful that this increase of $2 million or 2.3 percent over Fiscal Year 1986 levels of support is indicative of the Foundation's intentions to adequately fund science education activities. Further, NSF has repeatedly assured Congress that none of the funds appropriated to the program in either Fiscal Years 1986 or 1987 will be deferred into future fiscal years, as was the case between 1983 and 1985. The long-term gains of basic scientific research clearly will not be realized if the scientists and engineers of tomorrow are not adequately prepared today.

We believe, though, that the gradual rebuilding process undergone by SEE has prepared it to efficiently use additional support. Again, we urge the Committee to concur with the recommendations of H.R. 4184, as recently marked up by the House Science, Research and Technology Subcommittee. That measure contains an additional $4 million for SEE. These additional funds would bring the SEE Fiscal Year 1987 authorization to $93 million. We believe that this increase of nearly 7 percent above Fiscal Year 1986 funding is a sound investment.

ETHICAL RESEARCH ON SCIENCE AND TECHNOLOGY

APA would like to take this opportunity to commend the Members of this Committee and NSF Director Erich Bloch for actions taken to preserve long-term support of research on the ethical questions often raised by scientific advances. APA encourages NSF to continue its new mode of distributed funding for ethics and values research, and suggests that funding for these activities be raised from $500,000 in Fiscal Year 1986 to $1 million in Fiscal Year 1987 (the activity's level of support before the FY 86 budget cut). APA is particularly pleased that the Foundation is providing for the review of all projects in this area by an ethics advisory committee. It is essential for NSF to ensure that these studies will be properly coordinated and of high quality. As new mechanisms are being created to support these studies, APA encourages Congress to continue overseeing NSF support of research on scientific ethics and values.

BASIC RESEARCH AS AN INVESTMENT

The Administration has proposed significant increases for NSF-supported research -- even in the face of large federal deficits -- with the conviction that investing in basic scientific research will improve our competitiveness internationally and strengthen our scientific base at home. At least eight major studies released in the last three years recommend strong support for basic research. Groups recommending increased Federal support for basic research (which is less likely to attract support from the private sector than applied studies) include the Heritage Foundation, the National Association of Manufacturers, the AFL-CIO, the Business Roundtable, and Georgetown University's Center for Strategic and International Studies.

The behavioral and social sciences have a critical role to play in these efforts to revitalize the nation's economic and technological base. While our international competitors have been quick to recognize these contributions, increases in productivity that could be realized by modifying organizational structures and personnel policies have too often been passed over here in the United States. Indeed, the American Association for the Advancement of Science (AAAS), in Congressional testimony presented earlier this year, emphasized that in areas such as industrial productivity and innovation, "research findings from the behavioral and social sciences frequently are of greater consequence than those from the physical sciences and engineering."

While technological advances must figure prominently in revitalizing this nation's industrial base, human, social and institutional factors can play an even more important role. This is true whether one is addressing the conduct and management of research, the dissemination and marketing of new technical products, or the implementation of new manufacturing processes. A few examples follow:

1) Employee turnover is a costly problem in both the public and private sectors. Even when effects on the productivity of the organization

have been disregarded, behavioral scientists estimate that it will cost between $400 and $4,700 (depending on the nature of the position and the organization) to replace each departing employee. A major study of 20 different experiments designed to reduce employee turnover (McEvoy and Cascio, Journal of Applied Psychology, 1985, Vol. 70, No. 2, 342-353) found that programs aimed at "enriching" jobs on average reduced employee turnover by 17 percent. Thus for every 100 employees that an organization has in a particular job category, enriching or redesigning job tasks could save an average company between $6,800 and $79,900 per year.

2) A global study on the impact of organized programs designed to increase employee productivity in the workplace found that the average worker's productivity did, in fact, increase significantly (Guzzo, Jette and Katzell, Personnel Psychology, 1985, Sum. Vol., 38(2), 275-291). This study analyzed the findings of 100 separate studies covering 11 types of psychologically-based organizational interventions. Not all interventions were equally effective. The most powerful strategies, it was found, were in the areas of employee training and goal setting. Suprisingly, supplying employees with increased financial incentives did not reliably lead to increased productivity. The effects of worker incentive programs varied widely the study found, sounding a warning to those who depend solely on increasing compensation to boost productivity.

3) Research conducted in the United States following the second world war demonstrated techniques to increase the quality of mass produced units through increasing employee decisionmaking (Coch and French, 1948, American

Psychologist, 1982, Vol. 37, No. 7, 737-746). This social technology led to the training of production workers in rudimentary research design and statistical techniques enabling them to monitor and become more involved in the production process. This concept, which was originated in the United States, evolved into the unique Japanese technology, "quality control circles." The high overall quality of the Japanese automobile industry is attributable in part to the effects of quality control circles.

While there is a great need to conduct more research on the development of strategies and conditions critical to more efficiently utilizing the nation's human resources, such studies, for the most part, are not supported at the National Science Foundation. Primarily, NSF funding for the behavioral and social sciences has gone to support individual investigators pursuing the fundamental questions on human behavior and mental functioning. This is the type of work which forms the base for studies on improving productivity such as those already cited in this testimony. For example, social psychology research projects at NSF last year included basic studies on group opinion changes, social perception and the processing of social information. Findings emerging from these studies may be used to guide other behavioral scientists in devising strategies to be used in motivating employees. Similarly, basic research in the cognitive sciences last year included fundamental studies on knowledge acquisition, decision-making, and memory. Clearly advances in these areas are key to developing new, more effective educational and training strategies.

It is in the support of such basic, fundamental research in which NSF has the greatest role to play. Simply put, without the provision of additional financial inducements, support for these studies is rarely available from the private-sector since the ultimate payoff for these basic studies is often not readily apparent. Currently, behavioral and social science research is specifically excluded from the law which grants tax credits to industry in return for their support of basic scientific research.

Thank you again for the opportunity to present this statement. It has focused on the contributions that the behavioral and social sciences make to increasing the nation's productivity and international competitiveness. Of course, psychologists engage in many other areas of research. Their activities form an impressive array of inquiry which ranges from purely physiological phenomena to purely social phenomena and includes such diverse topics as normal and abnoramal brain growth and development; educational processes such as learning and memory; the study of social institutions and interactions; survey research; and the development of standardized tests with many applications in both the public and private sectors.

AMERICAN SOCIETY OF BIOLOGICAL CHEMISTS
—INCORPORATED—

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Serial 6-227
March 21, 1986

The Honorable Orrin G. Hatch
Chairman, Committee on Labor and
Human Resources
United States Senate
Washington, D.C. 20510

Dear Senator Hatch:

Thank you for your letter of March 12 inviting me, as a representative of the American Society of Biological Chemists (ASBC) to submit written testimony on the National Science Foundation (NSF) reauthorization for fiscal year 1987. What follows are a few thoughts on what we at ASBC consider to be generally a good budget for this important agency.

The Administration's request for the NSF budget for fiscal 1987 is a generous one, considering the severe fiscal constraints the federal government has been laboring under in recent years. Growth in the NSF budget of almost 9% is certainly justifiable, given the many research opportunities available today. We are also pleased that NSF Director Bloch has targeted research in biotechnology as one of the Foundation's four Special Emphases areas for this fiscal year.

However, while the request for fiscal 1987 more than compensates for inflation last year, this has not often been the case in the past. The NSF has, in fact, been consistently underfunded for many years. This is apparent by the fact that although the NSF budget has gone up by close to $700 million in current dollars in the past half dozen years, in real terms over the last twenty years, the NSF budget has barely kept abreast of inflation. The result of this unfortunate trend is that exploration of many promising lines of research has had to be postponed or abandoned because there simply has not been enough money. We hope that this year's authorization request represents the start of a trend in Congress toward consistent steady real increases in the funding of fundamental research at NSF.

The programs at NSF of most concern to us are those in the Molecular Biosciences, Cellular Biosciences, and Biotic Systems and Resources Divisions within the Biological, Behavioral and Social Sciences Directorate. We are pleased that funding for these programs is to be increased to $190 million in fiscal 1987, up from $175 million in fiscal 1986.

The Honorable Orrin G. Hatch
Page Two
March 21, 1986

NSF should have no trouble dispersing these funds. NSF will in all likelihood continue to attract excellent research proposals, particularly in light of the extensive and worrisome cutbacks proposed by the Administration for research funding at the National Institutes of Health, and the Alcohol, Drug Abuse and Mental Health Administration.

The major deficiency in the NSF authorization request is that science education programs received only a $2 million increase, to $89 million. We believe that increased funding for science education, especially at the primary and secondary school level, is certainly justified. Inadequate funding now will not affect the quality of research currently underway; however, over the long term, a continuing pattern of inadequate support will certainly impact negatively upon our nation. We therefore suggest that increased support for science education would improve what is otherwise a very defensible authorization request.

It is useful that the funds requested for science education no longer include "carry-overs" from previous fiscal years. This in itself is progress of a sort. Now that the Directorate is fully staffed, we hope that this year, all this money will be spent. It is certainly needed.

In closing, we are cognizant of the fact that this budget request is likely to be looked at very critically this year, since the NSF is one of the few research agencies where real increases are planned. We wish you success in your efforts to shepherd this bill through the legislative process, and offer our support in your endeavors. We also intend to work during the appropriations process toward full funding of whatever amounts are authorized.

Thank you for the opportunity to comment on this important matter, and we will be happy to respond to any specific questions you may have.

Sincerely,

Peter Farnham
Public Affairs Officer

PF:jsc

STATEMENT FOR THE RECORD

DR. ROBERT M. ROSENZWEIG

PRESIDENT

ASSOCIATION OF AMERICAN UNIVERSITIES

ON

THE FY 1987 REAUTHORIZATION
FOR THE NATIONAL SCIENCE FOUNDATION

THE COMMITTEE ON LABOR AND HUMAN RESOURCES
U.S. SENATE

ON BEHALF OF

ASSOCIATION OF AMERICAN UNIVERSITIES
NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES
AMERICAN COUNCIL ON EDUCATION
ASSOCIATION OF GRADUATE SCHOOLS
COUNCIL OF GRADUATE SCHOOLS IN THE UNITED STATES

MARCH 26, 1986

Mr. Chairman and Members of the Committee:

This statement is presented on behalf of five associations of universities and colleges. Together, they represent essentially all of the institutions of higher education that conduct federal research and related education programs. We appreciate the opportunity to offer the following comments on the FY 1987 Reauthorization for the National Science Foundation.

SPECIAL NOTE ON THE BUDGET:

Mr. Bloch is to be strongly congratulated for presenting, once again, a strong and well-balanced budget to the nation which affirms the critical importance of university-based science and technology, and demonstrating a welcome recovery of the Foundation's role in science education. If this were an ordinary year, with this budget before us, you would hear nothing but good cheer from me and my member universities.

However, this is not just an ordinary year. I do not believe that the NSF budget, or perhaps any other, can be considered by a Congressional committee without regard to responsibilities of the Members that go beyond their subcommittee and committee assignments and the agencies within their jurisdiction. Because of that, all of us in the university must acknowledge a pervasive sense of vulnerability that makes even good news suspect. Universities feel that vulnerability keenly because several essentially unrelated policy lines seem to be converging, and if they truly do meet, then there is the real prospect of very serious damage to those institutions and to the intellectual activity for which they are responsible.

The first set of policies to impinge on universities are those set in motion by deficit reduction pressures. NSF stands out among federal agencies for its proposed increase for FY 1987. That very fact may make it vulnerable as it moves through the Congress, but the main point is that virtually every other program on which universities rely (student aid, the NIH budget, and Medicare and Medicaid reimbursement) is slated for significant reductions and will force further reductions in institutional programs or the increase subsidization of those activities by other elements of the institution.

Second, the proposed revisions to OMB Circular A-21, recent published, which would cap particular components of indirect cost recovery, will hit the budgets of research universities heavily. When those rules take effect as proposed, losses in the millions of dollars a year will be incurred by individual institutions, and virtually all universities will suffer noticeable reductions.

The third line of policy converging on universities makes the effects of the first two even more devastating. The tax reform bill that passed the House last year contains a number of provisions that will simultaneously cost universities more money and severely undermine their ability to raise money from private philanthropy. The effect of these newly adopted provisions must be taken into account by anyone who cares about the health of

America's universities or the nation's capacities in science and technology.

Let me make it clear that none of the university presidents I know claims a special educational exemption from the solution of the nation's fiscal problems, nor do they ascribe these problems to some dark, anti-university conspiracy. However, all would, I think, argue that the combination of circumstances I have described exposes universities to special and largely unintended jeopardy, and they would wish that important fact to be considered by those who make policy for the nation.

Now I will turn to the specific highlights in the NSF budget. Mr. Bloch and the National Science Board together have clearly recognized that even in these difficult times we cannot afford to reduce our investment in academic science and engineering. Sustained budgetary stringency requires that we make difficult choices. In making these choices, we must sustain investment in the production of the two ingredients essential to our technological development, our economic competitiveness, our national security, and our health: the talent of our young people and our expanding body of new knowledge.

RESEARCH

Mr. Bloch has continuously emphasized that we have long recognized the unique benefits that result when national investments in education and research are combined in the university enterprise. Now more than half of all federal basic research programs are carried out in universities and colleges; NSF accounts for 25 percent of total federal basic research funding in universities. When students work with faculty engaged in national competitive research programs, research and education become the same activity. That bond forged between education and research is itself the unique strength of academic science and engineering. We are encouraged, therefore, to see that NSF proposed to further expand involvement of graduate and undergraduate students in many of its research programs. (In FY 1987, NSF estimates that 13,000 (+7 percent) graduate students, 4,500 (+25 percent) undergraduate students, and 3,700 (+4 percent) postdoctoral students will be participating as research personnel on NSF research grants.)

As the promising and important initiatives announced by the Foundation go forward, it will be critical to keep a close eye on the core activity of the Foundation--the individual investigator grant. The budget request for research and related programs gives special emphasis to biotechnology, computational science, and engineering and global geosciences. The cross-disciplinary engineering research centers (ERC) program proposes to create up to five new university centers jointly funded with industry. The advanced scientific computing activity will be strengthened, although no new centers are proposed. As presented, the budget sustains investment in competitive awards to individual researchers. It seeks to protect progress made in recent years to strengthen the average size and duration of Foundation grants. We trust that these gains will not be compromised by the development of the exciting new initiatives.

We are pleased to see that the social and behavioral sciences programs have recouped much of the loss imposed just a few years ago are restored. This reflects the renewed recognition of research potential in these fields to our productivity and security.

We would like to call to the Committee's attention one potentially anomalous aspect of the budget request: the request for astronomical sciences. Now when most research programs are slated to receive at least a measure of real growth, a reduction in constant dollars is proposed for the astronomical sciences. Because the NASA astronomical sciences budget is also under considerable strain this years, we hope the committee will review carefully the request for the astronomical sciences program in the context of the prospects for total federal support for the field.

GRADUATE FELLOWSHIPS

Again this year, the graduate fellowship program is level-funded. We understand that about 560 new awards are planned with a steady state of 1500 competitive fellowships. No adjustment in the student stipend is proposed. After making progress toward overcoming the effects of a decade of erosion, the program once again is beginning to lag significantly behind market forces competing for the best young undergraduate minds in science and engineering. The NSF program continues to provide stipends that are substantially below the small (40-50 awards per year) competitive program of the Office of Naval Research (ONR). The ONR program provides a first-year stipend of approximately $13,000 per year, full tuition, and a supplemental research award to departments selected by each ONR fellow.

For more than a decade, the cost of an NSF educational allowance has fallen steadily behind the actual cost of graduate education in the sciences and engineering. This year, we understand that the NSF program will take a step backwards by reducing the cost of an education allowance (now only $6,000) that accompanies each NSF fellowship. Rather than cover even the cost of tuition (which itself does not cover the actual costs of instruction), the NSF program continues to require host universities to subsidize the program from their own funds and to do so by steadily increasing amounts. This remains a troublesome and growing inequity in the program.

We understand that the Foundation proposes to absorb the reductions required by the Gramm/Rudman/Hollings Balanced Budget Act by absorbing the entire reduction in the cost of education allowance. This step, it seems, is inconsistent with recent attempts to bring the program into line with present costs. We urge the committee to ask the Foundation to sustain at least present funding levels for the cost of education allowance.

UNDERGRADUATE SCIENCE AND ENGINEERING EDUCATION

The NSF proposes a modest increase for science and engineering activities. With the exception of the College

Science Instrumentation Program, which is increased by $2 million in order to fund between 75 and 80 new projects, all programs are maintained at their FY 1986 level. Although we are pleased to see an expanded commitment to addressing this area, especially in our schools of engineering, the present program level is only a first step.

INSTRUMENTATION AND FACILITIES

The Foundation has made substantial progress in identifying and meeting the research instrumentation needs of Foundation-funded investigators. Now about 20 percent of total NSF research funds are allocated to the acquisition of research equipment. We commend the Congress and the Foundation for sustaining a strong commitment to addressing the research equipment problem.

We must point out, however, that little progress has been achieved in meeting the needs of research institutions to replace and modernize laboratories in which national research programs are conducted.

We understand that the White House Science Council recommends that the National Science Foundation undertake a research facilities modernization program. While we recognize the present barriers to making progress toward programmatic solution, we are encouraged that the general characteristics of the problem, its seriousness and a federal responsibility to help fashion solutions are now more widely recognized. We also are encouraged that the Foundation, as directed by the Congress last year, is developing a capacity to assess the problem in a comprehensive way. We hope that this committee will give the facilities problem further attention when the first NSF report is compiled later this year.

We thank the Committee for the opportunity to present our views on these issues critical to the future of our nation.

CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS
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STATEMENT OF THE CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS (COSSA)

David Jenness
Executive Director

on the
FY 1987 BUDGET FOR THE NATIONAL SCIENCE FOUNDATION

Prepared for the
COMMITTEE ON LABOR AND HUMAN RESOURCES

U.S. SENATE

The Honorable Orrin Hatch, Chairman

March 25, 1986

American Anthropological Association • American Economic Association • American Historical Association • American Political Science Association
American Psychological Association • American Sociological Association • American Statistical Association
Association of American Geographers • Association of American Law Schools • Linguistic Society of America

The Consortium of Social Science Associations (COSSA) represents more than 185,000 American scientists across the full range of the social and behavioral science disciplines. It functions as a bridge between the research world and the Washington community. A list of COSSA Members, Affiliates, and Contributors is attached.

COSSA would like to take this opportunity to comment on the proposed budget for the National Science Foundation (NSF) for FY 1987. The overall increase of 16% over FY 1986 post-Gramm-Rudman-Hollings levels proposed for NSF is indeed welcome in this era of deficit reduction. Maintaining the investment in basic research is essential to the economic competitiveness and security of this nation. Investment by the Foundation in social and behavioral science research demonstrates a recognition of the substantial contributions these sciences make to those important national goals. Reducing this commitment would decrease the quality of our scienctific endeavors and inventiveness.

The 14% increase for Research and Related Activities in FY 1987 over FY 1986 post-Gramm-Rudman-Hollings levels is also welcome. We strongly urge the maintenance of that increase during the Committee's deliberations. Although they are not as substantial as the increases proposed in FY 1986, the increases for FY 1987 in the Division of Social and Economic Science and the behavioral science programs in the Division of Neural and Behavioral Science reflect continued support for these disciplines. We are quite pleased with the substantial increase for the Division of Information Science and Technology where approximately 40% of the awards go to social and behavioral scientists.

We are especially pleased that the social and behavioral sciences will share in some of the special emphases of the Foundation for FY 1987. The Decision and Management Science program's increased funds for risk assessment, the Geography program's increase for computerized mapping and physical geography, and the continued support for more sophisticated computerization of the social and behavioral science data bases, are indications of NSF's involvement of the social and behavioral sciences in its targeted research priorities.

Despite all this pleasure we are not satisfied. Although, if the FY 1987 proposed funding levels are maintained, the social and behavioral sciences will have finally been restored to their FY 1980 levels in current dollars, support for these sciences at NSF is 27% below the 1980 levels in constant dollars (see Exhibit A). In FY 1987 we remain at only 4% of the NSF research and related activities budget, a figure that has declined over the past four years, and is a full 2% under the FY 1980 share of that budget.

COSSA believes that the Committee should increase funding so that 5% of the Research and Related Activities budget goes to social and behavioral science research. This would mean adding $14 million to the FY 1987 proposed funding. We believe this is a justifiable goal given the intellectual vitality and ferment in these sciences and their importance to the nation.

We are also not satisfied with the small increase for the Directorate for Science and Engineering Education (SEE). For too many years now the Foundation has stalled in supporting a full and vital SEE Directorate. The small increase proposed for FY 1987 comes on top of a deferral of FY 1985 appropriated funds. This Directorate which supports research in teaching and learning and the education and training of new scientists deserves greater support than it is getting from the Foundation.

Mr. Erich Bloch, Director of the National Science Foundation, argues in favor of basic research "as a force for present and future competitiveness" of the United States. It is clear that social and behavioral science research plays a vital role in competing in an international economy driven by science and technology. Economic competitiveness is achieved not only by developing new and better products, but also by understanding how to interact with those products, how to use them, how to manage the people who make them, in other words, the human behavior side of technological advancement. It is in these areas and others that social and behavioral science research offers the nation the resources and results to compete.

A sampling of the scope and nature of work in these sciences indicates the contributions, those already made and those with great potential, that continued and increased support from NSF will foster:

● Advances in theoretical economics and econometric modeling have led to advances in economic forecasting and economic policy. Although, economic forecasting is not perfect, these advances have narrowed the range of disagreement among economists in their ability to help policy-makers. As Herbert Simon has pointed out, the major differences that remain result from different assumptions about how people form expectations, a question that is now the focus of much social and behavioral science research.

● Great advances in statistical techniques, such as multidimensional scaling, have produced sophisticated methods of data analysis. These techniques continue to undergo improvement.

Refinements in survey research methodology will produce more accurate indicators upon which many of our economic decisions are based. The access of social and behavioral scientists to new generations of computers will enhance these activities.

- The need to construct computer models of the international economy to adequately monitor its behavior is another activity where economists are playing a significant role in contributing to U.S. competitiveness.

- The theory of rational-decision making remains one of the major accomplishments of the social sciences in the past. Yet recently social scientists have discovered its limitations. The ability to determine how people, from elite policy makers in government and business to the man and woman in the street, make individual choices will strongly affect how the U.S. fares in this competitive world.

- Advances in cognitive psychology have led to experimentation that helps us understand how people process information and perform complex tasks. These techniques are being applied to important problems in education, business and professional decision-making, and man-machine interaction. All of these are related to keeping America on top scientifically and economically.

- Advances in the study of sensory perception have allowed us to understand how people perceive complex stimuli. The military is particularly interested in auditory and visual perceptions in order for their personnel to operate in multidimensional auditory and visual environments. A modern military reacting positively in complex environments keeps America secure.

- Linguists are working on models, many of them computerized, of how children acquire and transmit their native language. These studies have led to the development of instruction packages, some computer-aided, to teach our children and others the language skills, both native speaking and foreign, that are needed to compete in an international economic setting.

- Keeping Americans healthy and productive is a major factor in maintaining the competitive edge. The work of social and behavioral scientists in relating good heath to behavioral factors has contributed to increased consciousness of how people control their own quality of life. This is especially true in keeping our rapidly aging population active, productive, and free of dependence on costly health care and maintenance.

- Research on criminal careers and career criminals has developed insights into why a portion of the population decides that illegal productive enterprise is more attractive than legal productive enterprise. America loses substantial dollars and sometimes talent to these illegal activities, creating more competitive disadvantages. Understanding why and developing methods to rechannel these activities can lead to more productive lives for these people and safer lives for everyone else.

- Studies of agenda formation and agenda setting in organizations demonstrate the importance of the agenda itself in decision-making. How issues reach the national agenda of government often determines the response to those issues. External challenges often focus our energies more than internally determined responses.

- How the United States competes internationally depends on our understanding of other governments and cultures. Social and behavioral scientists contribute to that understanding by focusing on international aspects of political, economic, and social choices. Evaluating the impact of different electoral systems on policy making, explaining international economic systems, and examining social and cultural differences of foreign nations have long been the purview of social and behavioral scientists.

- Direct utilization of social and behavioral science research on management styles and worker participation has revolutionized the automotive industry in this country. It is a shame that the Japanese and Swedes paid attention to this research earlier than our American companies. As sociologist William F. Whyte notes, it took the shocks of international competition to persuade industrial leaders in the United States of the need to make basic changes based on the organizational behavior literature.

- Research on the interaction between people and technology has led to attempts to revitalize America's shipping and shipbuilding industries. The work of Einar Thorsrud in Norway involving physically re-designing ships and reducing social and status differences among people on the ships, has formed the basis of changes in human resource utilization in the U.S. maritime industry.

- Social scientists are being called upon by State governments to conduct policy research and technical assistance designed to aid in the revitalization of U.S. industry.

- Examining the impact of Employee Stock Ownership Plans (ESOPs) and worker cooperatives is another example of social science research contributing to better understanding of economic productivity to keep this nation competitive.

A briefer sampling of the research in social and behavioral sciences further suggests the vitality and ferment that make support for these sciences so important to continued economic competitiveness. Topics currently being studied include:

- microsimulation models to help target federal funds to those who most need them;
- human adaptation to stressful environments;
- assessment of risks in occupational settings;
- attracting more women and minorities into science;
- developing computerized models of transporting food from surplus areas to deficit regions in countries around the world;
- youth unemployment; female participation in the labor market; why people change jobs;
- economic constraints on single parent households;
- understanding and predicting human responses to natural and technological disasters;
- comparing the largest metropolitan areas of the country concerning urban land use, population distribution, transportation use, and other critical urban functions;
- social components of alcohol and drug abuse;
- decision-making by farmers and their response to the agricultural crisis;
- the impact of different housing arrangements on the elderly;
- the impact of inflation and deflation and other economic changes on American families;
- the cognitive capabilities of very young children and ways to cope with a teacher shortage for this group.

These lists are by no means exhaustive. They are presented to illustrate that these sciences are conducting research into all areas of human activity that affect the current and future productivity and competitiveness of this nation. As we said last year, research in social and behavioral science does not always yield the solution to the problems it investigates, but increasingly it provides decision-makers with the information to make better and more informed decisions.

We would like to thank this Committee for its support of the social and behavioral sciences in the past. We call on you to move toward more equitable support for these sciences by increasing their allocation within the NSF budget.

Thank you for allowing us to present our views.

NOTE:
USED FY82 DOLLARS
FROM FY80 ON

HISTORY OF SOCIAL AND BEHAVIORAL SCIENCE FUNDING AT THE NATIONAL SCIENCE FOUNDATION

	FY80	FY81	FY82	FY83	FY84	FY85	FY86 (EST)	FY87 (EST)
SOCIAL AND ECONOMIC SCIENCES (Current Dollars)	$31.4	$25.1	$17.6	$20.3	$24.6	$28.6	$28.6	$31.4
(Constant Dollars)	$37.1	$26.9	$17.6	$19.5	$22.7	$25.5	$24.7	$26.0
BEHAVIORAL SCIENCES(BNS)*-(Current Dollars)	$21.1	$18.5	$15.0	$16.6	$18.6	$23.3	$21.3	$23.6
(Constant Dollars)	$24.9	$19.8	$15.0	$15.9	$17.2	$20.8	$18.4	$19.6
TOTAL BEHAVIORAL AND SOCIAL SCIENCES-(Current Dollars)	$52.5	$43.6	$32.6	$36.9	$43.2	$51.9	$49.9	$55.0
(Constant Dollars)	$62.0	$46.8	$32.6	$35.4	$39.9	$46.2	$43.0	$45.6
GNP Deflators	0.85	0.93	1.00	1.04	1.08	1.12	1.16	1.21

*Includes psychobiology
Source: NSF Budgets to Congress, FY 1976-1985
12/11/84

EXHIBIT A: Source: The National Science Foundation

Consortium of Social Science Associations

Members

American Anthropological Association
American Economic Association
American Historical Association
American Political Science Association
American Psychological Association
American Sociological Association
American Statistical Association
Association of American Geographers
Association of American Law Schools
Linguistic Society of America

Affiliates

American Association for Public Opinion Research
American Educational Research Association
American Evaluation Association
American Society of Criminology
Association for Asian Studies
Eastern Sociological Society
Economic History Association
Gerontological Society of America
History of Science Society
International Studies Association
Law and Society Association
Midwest Sociological Society
National Council on Family Relations
National Council for the Social Studies
North Central Sociological Association
Northeastern Anthropological Association
Operations Research Society of America
Population Association of America
Regional Science Association
Rural Sociological Society
Social Science History Association
Society for American Archaeology
Society for the History of Technology
Society for Research in Child Development
Society for the Scientific Study of Religion
Southern Sociological Society
Southwestern Social Science Association
Speech Communication Association
The Institute of Management Sciences

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FEDERATION OF BEHAVIORAL, PSYCHOLOGICAL AND COGNITIVE SCIENCES
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TESTIMONY OF

Federation of Behavioral, Psychological and Cognitive Sciences

on the subject of

REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION

prepared for

COMMITTEE ON LABOR AND HUMAN RESOURCES

UNITED STATES SENATE

The Honorable Orrin G. Hatch, Chairman

March 25, 1986

American Educational Research Association • American Psychological Association • Cognitive Science Society • Human Factors Society •
International Society for Developmental Psychobiology • National Academy of Neuropsychologists • Psychometric Society • Psychonomic Society •
Society for Computers in Psychology • Society for Mathematical Psychology • Society for Psychophysiological Research •
Society for Research in Child Development • Society of Multivariate Experimental Psychology

This statement is prepared by the Federation of Behavioral, Psychological and Cognitive Sciences. The Federation, established in 1980, is a coalition of 13 scientific societies with combined memberships of over 90,000. The Federation's interests include research on behavioral, psychological and cognitive processes and their physiological bases and its application to education, health and human development. We are pleased to comment for the record on the reauthorization of the National Science Foundation.

As scientists we are pleased with the Administration's active support of Federally funded basic research, as reflected in the proposed NSF FY87 budget. It is important to the nation to maintain a strong Federal role in basic research even as the Congress is making major steps to reduce the Federal deficit. In fact, consistent funding for NSF, whose sole mission is to support basic science, now is more important than ever.

Research results cannot be bought on a short time scale. Neglecting basic research this year means fewer gains in subsequent years. We will not be able to remedy this deficit by increasing research spending at that later time. Good research requires attracting good people to work on important problems, training new researchers, obtaining basic results and working out their applications. None of this can be done quickly; the investment in ideas, methods, and applications must be made now. That is why it is important for the government to maintain and enhance, wherever possible, its support for basic research.

In this testimony we would like to call to the Subcommittee's attention the critical importance of research in the behavioral and cognitive sciences and science education.

Behavioral and Cognitive Sciences

The human mind is really our biggest economic resource. The prospects of increasing human productivity lie in improving the productivity of the human mind. One way is by using technology to augment human thinking. Another is through research on cognitive processes, which has the potential of enhancing our own abilities to think and solve problems and to improve education and training.

The nation faces serious difficulties in adjusting to new information technologies in the work place and in finding productive ways to utilize new technologies to increase the productivity of our industrial and educational institutions. Results of research in behavioral and cognitive sciences are already being used in the design of new human-machine systems, the development of programs of training and education and the improvement of the working environment for many in our nation's work force.

Traditionally one thinks of automation in terms of job productivity and job availability. However, automation affects the role of the supervisor of complex equipment and systems. Examples are airline pilots, power plant control room operators or intensive care nurses. These jobs can shift from boring (when everything is running smoothly under computer control) to overwhelming (during an emergency) in brief periods of time. Technology assists in performance, but it raises a new set of issues: Should systems make their own decisions? Should they inform the operator of every action they take? Do these systems create or eliminate workload? Much of the basic research that will help answer these questions is in the areas of decision making, problem solving, perception and motor skills.

Continued improvement in the use and development of technology requires solutions of fundamental scientific problems regarding the nature of human understanding, learning and motivation. We need to understand more about the cognitive skills and knowledge required for successful performance in technical domains. We need to study how people understand technological systems in order to assure an optional design for human use and comprehension. As we become increasingly dependent on electronic graphics for communication, scientific progress in understanding thought processes will contribute critically to the design of computer-based visual displays. Characterizations of the mental models that people use in reasoning provide a basis for better design of technical information systems and training in the use of technical systems.

In addition, recent basic research on visual perception and attention and spatial orientation is now changing, for example, our understanding of nighttime driving. These results have implications for driver education, night driving speeds, and headlight and highway lighting requirements.

How do people rapidly identify the meaning of a visual symbol? Perhaps more interesting, why is it that people who have large vocabularies are quicker at recognizing simple words? What sort of information retrieval system gets better as its data base increases? Substantial advances in our understanding of word recognition are made by exploring computational parallels of the process. An area of increasing importance is psychobiology, an area which links research in brain processes with our understanding of behavior. Fundamental insights into the biological basis of memory, for example, can be expected in the coming years.

Science Education

The need for strengthening our nation's educational programs in mathematics, science and technology is broadly recognized. In turn, this means that we need to improve our understanding of the processes of problem solving, comprehension, learning, teaching and testing to guide the development of new educational resources, including the effective use of new computational technology in both instruction and testing.

It is clear that effective science education will result only from the efforts of both the science and education communities. We support interdisciplinary research efforts by behavioral and cognitive scientists, content area scientists and science educators.

Research on problem solving has provided significant new information about cognitive processes and knowledge--demonstrating the kinds of knowledge required for successful problem solving and providing explicit descriptions of knowledge relevant to selected domains in science and mathematics. For example, a predominant view underlying current curriculum design and teaching in science is that students' understanding of scientific concepts is shaped by their instruction. Much care is taken to avoid presenting incorrect principles or concepts. However, students begin their study with strongly held conceptions of phenomena that are explained by scientific principles. Even young children are curious about their world--how things work as well as their classification. When children do not receive much formal science education until high school or college, misconceptions of scientific concepts are allowed to develop. Research shows that their preconceptions are often inconsistent with the principles to be learned but persist even after considerable instruction. As a consequence, students may be able to use their formal knowledge to correctly solve textbook problems but still base their understanding of events of the world on their incorrect preconceptions when taught with commonly used methods.

Many of the research findings are important for educational practice. Recent information about the sources of difficulty in understanding mathematical, scientific and technical concepts provides a basis for development of educational materials and methods for reaching a broader group of students. Research to identify factors contributing to relatively low levels of participation in mathematics and science courses by women and members of minority groups is underway and is suggesting ways in which increased participation can be developed.

Research in cognitive science is not only changing our views of how people learn science and mathematics, it is also shaping a theory of learning in which content plays a central role. The approach implies that much of the research in teaching and learning in science will be done in the context of the science being taught.

As with any science, research relevant to education in mathematics, science and technology is cumulative. It requires continuing support if it is to sustain and expand its impact in education. Continued NSF support is therefore critical.

Conclusion

We recommend that you continue to support fundamental science research by reauthorization of NSF funding at the level of the Administration's FY87 budget. This is the minimal amount necessary to insure building on your previous investment.

The Federation appreciates the opportunity to submit these comments. Please do not hesitate to call on the Federation staff if we can be of further assistance during your deliberations.

Statement on Science at Undergraduate Institutions,

by President Jon W. Fuller of the
Great Lakes Colleges Association,
for the Senate Committee on Labor and Human Resources
submitted March 25, 1986

Mr. Chairman:

I am Jon Fuller, President of the Great Lakes Colleges Association. I am pleased to have been invited to submit a statement to this committee as you consider reauthorization of activities of the National Science Foundation. In appearing here today, I am representing the twenty-five liberal arts colleges which are members of the Great Lakes Colleges Association and of the Associated Colleges of the Midwest.* Reed College in Oregon and Connecticut College also join in supporting our position.

The original authorization of the National Science Foundation gave it a dual responsibility both to support the most promising basic research and also to provide for our future scientific capacity through the support of science education at the undergraduate and pre-college levels. Our national security and our economic well-being rest on our continued excellence, both in current research, and in development of an adequate number of scientists, teachers of science, and technicians for the future. We are pleased to see that, after a period of serious and dangerous neglect, the National Science Foundation has renewed its commitment to this second part of its mission, "the development of properly educated and trained people, the human resources pool that provides the scientists and engineers for the future," as the NSF Director, Mr. Bloch, aptly put it in introducing the Foundation's fiscal 1987 budget proposals.

It is extremely important that the process of science education and the education of scientists be seen as continuous. The undergraduate years represent a crucial phase in this process, the last point at which qualified students can chose careers in science—and unhappily, the time during which significant numbers of qualified students are chosing not to pursue careers in science. A declining proportion of American undergraduate students express an intention to major in science, and each year fewer baccelaureates are being awarded for the completion of science majors. This is happening at a time when every projection of our future needs indicates that we will need larger numbers of scientists, teachers of science, and appropriately trained technicians to sustain our scientific and economic activity. This decline in interest in scientific careers extends to the graduate schools, where we have seen a significant drop in the number of new Ph.D.'s they award each year in the physical sciences, mathematics, and engineering. A real danger to us as a nation is the fact that the number of American citizens among those science Ph.D.'s has declined even more sharply than the total numbers would suggest. An increasing proportion of the graduate school enrollment in the sciences and particularly in engineering is now made up of foreign nationals. As NSF Director Bloch recently put it there is a real danger that pursuing a Ph.D. in the physical sciences and engineering is "becoming an un-American activity!"

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*The Great Lakes Colleges Association is a consortium of twelve undergraduate liberal arts colleges: DePauw, Earlham, and Wabash in Indiana; Albion, Hope, and Kalamazoo in Michigan, and Antioch, Denison, Kenyon, Oberlin, Ohio Wesleyan, and The College of Wooster in Ohio. The Associated Colleges of the Midwest includes thirteen undergraduate colleges: Colorado College; Knox, Lake Forest, and Monmouth in Illinois; Coe, Cornell, and Grinnell in Iowa; Carleton, Macalester, and Saint Olaf in Minnesota, and Beloit, Lawrence, and Ripon in Wisconsin.

The colleges which I specifically represent, and others like them across the country, take pride in the fact that our science enrollments have not declined. We also take pride in the continuing contributions of these institutions in sending their graduates on to complete Ph.D.'s in the sciences. That contribution is particularly striking when one takes account of the smaller institutional size of most of these colleges, compared to the large universities. I have attached to my testimony a summary of recent research by Dr. Carol Fuller of our staff which identifies the most productive undergraduate sources of Ph.D.'s as measured by the percentage of their graduates going on to complete those degrees.

One response to this situation must be to support the success of these colleges which have managed to sustain undergraduate interest in the sciences. But it is also important to look at the undergraduate experience across the whole spectrum of higher education institutions, and to strengthen the quality of science instruction during those very important four years.

Because the production of scientists, teachers, and technicians is a continuous process, science instruction in the elementary and particularly in the secondary schools must also command our attention. The colleges with which I work most closely are finding a great range in the quality of preparation in mathematics and science among freshmen who come to us. Some of it is really very good. But the overall grade must still be rated as "poor." A significant part of the problem is that we are losing qualified secondary school science teachers, drawn away by larger salaries and more attractive professional opportunities. A significant part of the responsibility for dealing with the situation in our elementary and secondary schools certainly lies at the local and state level. That is particularly true in terms of trying to deal with the difficult issues of appropriate levels of compensation for teachers generally, and specifically for those in fields like the sciences and mathematics. But the federal government can have an important and useful role in upgrading and sustaining the qualifications of those who do chose careers in teaching science in our elementary and particularly in our secondary schools. In-service and summer institutes, now being sponsored by NSF, are certainly useful. Cooperative links between schools and colleges and universities are also very helpful, and we hope that NSF will be more active in encouraging and supporting those kinds of linkages. Because such an important part of the problem seems to be sustaining the sense of professionalism for teachers of science, we need to look carefully at programs of recognition and encouragement for these important people. One promising development, now being supported on a very experimental basis by NSF, involves including secondary teachers in research activities in colleges and universities, particularly during the summer, as a way of recognizing and sustaining their commitment as scientists.

Let me turn now to the specific needs at the undergraduate level. The National Science Board established a committee early this summer to address problems of science at the undergraduate level. In the initial charge to that group, the chairman of the National Science Board, Dr. Roland Schmitt, acknowledged that "currently no systematic federal leadership or support exists for science, engineering and mathematics education at the undergraduate level." We await the report from the National Science Board this month. We would be happy to comment on their report for this Committee when it is available. But we already know that an important part of their deliberations was the contribution of the Higher Education Associations' Task Force, which was coordinated by the American Council on Education. In that group's report, the first priority was placed on the need for instructional scientific equipment and materials. The experience of the colleges with which I work most closely confirm that priority. Both research and instruction in sciences increasingly requires equipment which reflects the rapidly advancing "state of the art." Helping institutions to aquire this desperately needed equipment represents a very productive use of federal resources.

The National Science Foundation now offers two programs which can assist colleges and universities in meeting their equipment needs. The first of these is the College Science Instrumentation Program. There have been far more quality proposals to this program than it has been possible for NSF to fund. We are therefore very pleased that NSF is proposing a $2,000,000 increase for CSIP for fiscal 1987. I certainly hope that increase will receive congressional approval. We understand that in this next year, NSF intends to focus the increase particularly on the needs of engineering schools. Frankly, we would prefer to see the program continue to be open to undergraduate institutions on a fully competitive basis, with the increased funding going to those places presenting the best proposals. We certainly don't deny that there are needs in the engineering field, but there are needs which are not being met across the undergraduate spectrum, and we believe that a competitive peer review is still the best way to make hard choices. An important feature of the CSIP grants is their requirement of matching dollars to be raised by the institutions. This also represents a very useful way of extending the value of the federal investment.

It has also been possible to support research instrumentation (which at any good undergraduate college always has instructional uses as well) through the research directorates' funding of proposals under the Research in Undergraduate Institutions Program. Instrument support has been one of the most valuable products of this program, and we certainly hope that it will be sustained.

A second need for undergraduate institutions is research opportunities for their scientists. This is now being provided primarily through NSF's Research in Undergraduate Institutions Program. Frankly, there have been some problems because of the highly decentralized nature of this program's administration. Some directorates have been very responsive to RUI priorities, while staff and reviewers in other parts of the agency continue to reflect not only a lack of understanding but even hostility to the idea that good research can be done by scientists whose primary focus is on the teaching of undergraduates. We hope that this committee will join us in continuing to press NSF leadership for accountability in actually delivering on the promises of the RUI program.

Support of research being done by faculty members who are actively engaged in teaching undergraduates simultaneously produces good and needed research results and also uniquely important education for future scientists. The research done by scientists at undergraduate institutions can be just as good as that done in any setting across the country. Because of its scale and pace, research conducted at undergraduate institutions can make uniquely valuable contributions to science. It is important, however, as the RUI guidelines try to make clear to reviewers and staff members, to recognize that work done by a scientist with major undergraduate teaching responsibilities must inevitably come at a slower pace and that the quantity of published results will be less, although the quality can be competitive with that of scientists whose primary responsibility is research.

There is another advantage in research which is done by scientists at undergraduate colleges: it is typically carried out as an extension of teaching, involving the most promising undergraduates. This is one of the reasons that support of research by faculty at undergraduate teaching colleges has a double value: the quality of the research itself, and the contribution it makes to the education of some of our best future scientists. In background materials done for a conference held at Oberlin last summer, which brought together 48 good liberal arts colleges with a strong record in science productivity, it was noted that the science faculty at those institutions had produced approximately 7,000 articles in the past 5 years, and that a third of those had been co-authored with undergraduates.

One of the most valuable programs of the NSF's Science Education Directorate was the Undergraduate Research Participation program. Unfortunately, it was abandoned by the agency several years ago, as part of their effort to shed that important part of their overall mission. As that trend is being reversed at NSF, we are pleased that funding for undergraduate research participation is back on the agency's agenda. We wonder why the Science and Engineering Education Directorate is not being called upon to administer this program, with the education of undergraduates as its principal purpose; URP was an exemplary program, both in review and operation, when it was operated under that aegis earlier. The fiscal 1987 budget summary mentioned plans to support bringing together "small groups of students to participate in the conduct of research." There appears to be an interest in having that take place at major research laboratories, and that certainly is one appropriate way of organizing undergraduate research opportunities. It is also important to fund such activities at undergraduate campuses, so that some of the research work can go on during the academic year, and not just in the summer as part of a special program. As Mr. Bloch has noted, "once students enter their third or fourth years, the best way to prepare them to undertake graduate work is by increasing opportunities to participate in research activities."

The Associated Colleges of the Midwest and the Great Lakes Colleges Association are currently conducting a survey of past participants in the URP program, to identify the influence of that experience in their subsequent careers. When that survey is completed, we will certainly report its findings to this committee as well as to the Foundation. The preliminary and essentially anecdotal results are, not surprisingly, a strong endorsement of the value of research experience during the undergraduate years.

It has been possible to support undergraduate research experience as part of the RUI program. There has been great unevenness in the agency, however, in the degree of understanding by staff and reviewers about the value of that element of any research proposal.

The NSF is on the right track in its plans to resume support for undergraduate research participation. We hope that this will have your committee's full support. It represents an important and definitely cost-effective investment in our future scientific resources.

One area which is still not being adequately addressed by any NSF efforts involves the broader professional development of science faculty members who teach at undergraduate institutions. Opportunities to do research are an important part of professional development for those scientists whose primary responsibilities involves the teaching of undergraduates. But they also need periodic opportunities for professional renewal. They need to work with and consult with scientists at larger laboratories, as a supplement to the research activity which they can carry on there and on their own campuses.

Faculty at undergraduate campuses are called upon to teach a broader range of courses than are colleagues at larger and more specialized institutions, and they have special needs to keep up with a wider field of knowledge. The Science Faculty Fellowships at one time filled this need by providing faculty, who did not teach in research institutions, with support to spend time in an academic or industrial research setting working on projects directly related to improving their teaching. We are pleased to see NSF recognition of this need in the fiscal 1987 budget summary, which included a promise that "traditional activities such as research sabbaticals, participation in industrial research, and special short courses and workshops will be supported." The Research Opportunity Awards, which are being advertised more vigorously by NSF, provide one type of opportunity for faculty members at undergraduate colleges to have the professionally renewing experience of being part of research activities at a larger research laboratory. But more general and flexible support is also needed. We hope that NSF and this Committee will look carefully at the successful programs of the past—particularly the Science Faculty Fellowships—as models for the ways to carry on this important element in the support for undergraduate science.

For next year, the NSF is proposing a new program, focused on the needs to recruit larger numbers of minority students into the sciences, which will involve funding of Minority Research Centers of Excellence. We think this idea, successful in the past as Resource Centers for Science and Engineering, has promise to be extended to other undergraduate institutions in the future. The general idea is to provide sustained NSF support to build on areas of existing strength. Those can then be used as models and resources by other institutions whose programs are still building.

We are gratified that NSF has in its budget document noted its intention to serve some of the needs of undergraduate science education. We eagerly await details and reassurances about the administration of these intitiatives. The Science and Engineering Education Directorate has useful connections with the undergraduate community. Their involvement could contribute to the success of these initiatives, as proven by the popular College Science Instrumentation Program (CSIP).

We believe that this Congress and the Foundation should also look seriously at the possibility of a program of challenge grants to assist institutions in raising the significant capital which is needed to restore various facets of the undergraduate scientific base. Such challenge grants have worked very well at the National Endowment for the Humanities. They provide excellent leverage for the Federal dollars invested.

One general point about the operations of the National Science Foundation and its responsiveness to the needs of undergraduate institutions needs to be made: the Foundation's advisory committees and review panels include very few scientists from undergraduate institutions. It seems clear that many of the problems in the actual execution of NSF's new and welcome efforts to assist undergraduate education come from a lack of understanding about the realities of science in such institutions. The Director, Mr. Bloch, has publicly acknowledged the need to increase significantly the numbers of scientists from undergraduate institutions who serve on these committees and panels. But actual progress seems painfully slow, and this is a real impediment to carrying forward the Foundation's new and very important emphasis on the undergraduate sector of the scientific enterprise.

A particular concern is the membership of the National Science Board. When that group, with urging from the Congress, turned its attention to undergraduate science early last summer, it was necessary to recruit an outside member for their committee (President James Powell of Franklin and Marshall College) because no member of the National Science Board had direct experience with science at undergraduate institutions. It is clear that President Powell made a vital contribution to the work of that group. The continued presence of scientists with undergraduate college backgrounds in the deliberations of the National Science Board would ensure that we do not again see this important part of the Foundation's mission neglected, and that the efforts to carry it forward are indeed appropriate and effective. We ask this committee to urge the National Science Foundation to see that appropriate candidates are nominated to fill a certain proportion of the seats on the National Science Board, so that this gap in its membership experience is filled. Please also press NSF to carry through on the commitment to add scientists from undergraduate institutions to the other Foundation advisory committees and review panels as well.

We are delighted that this committee and the National Science Foundation have, by their renewed attention to issues of undergraduate science, joined in bringing about important and overdue changes in emphasis and priority for our federal science policies. We are prepared to cooperate in any way we can to provide you with the information you may need to evaluate this aspect of the National Science Foundation's mission as you consider reauthorization of its activities for the years ahead.

I would be happy to answer any questions which members of the committee may have.

Attachment

Leading Undergraduate Sources of Science Ph.D's, Adjusted for Institutional Size

Institution	Total	Ratio
California Institute of Technology	1781	39.2
Harvey Mudd (CA)	247	39.1
Reed (OR)	766	20.0
Massachusetts Institute of Technology	5141	19.9
Chicago (IL)	2592	16.6
Swarthmore (PA)	975	14.4
Cooper Union (NY)	586	13.4
UC-San Diego (CA)	325	12.4
New College of the U. of South Florida	48	11.7
Haverford (PA)	415	11.4
Webb Institute (NY)	47	11.2
Rice (TX)	1192	10.8
Harvard (MA)	3527	10.3
Oberlin (OH)	1347	10.3
Pomona (CA)	713	9.2
Brandeis (MA)	578	8.7
UC-Riverside (CA)	709	8.7
Carleton (MN)	631	8.7
Eckerd (FL)	77	8.5

Leading Undergraduate Sources of Science Ph.D's (continued)

Institution	Total	Ratio
Rensselaer Polytechnic Institute (NY)	1819	8.5
Wabash (IN)	324	8.4
Amherst (MA)	642	7.9
Cornell U. (NY)	4213	7.9
Antioch (OH)	620	7.8
UC-Irvine (CA)	253	7.8
Johns Hopkins (MD)	1207	7.8
Polytechnic Institute of New York	935	7.6
Princeton (NJ)	1765	7.6
Grinnell (IA)	450	7.3
Wesleyan (CT)	511	7.2
Carnegie-Mellon (PA)	1422	7.0
New Mexico Institute of Mining	111	7.0
Kalamazoo (MI)	307	6.7
Columbia (NY)	2553	6.6
Yale (CT)	1996	6.5
UC-Santa Cruz (CA)	192	6.4
CUNY: City College (NY)	4990	6.2
SUNY: Stony Brook (NY)	597	6.2
Wooster (OH)	527	6.2
Case Western (OH)	1751	6.0
Philadelphia College of Pharmacy (PA)	252	6.0

Leading Undergraduate Sources of Science Ph.D's (continued)

Institution	Total	Ratio
Stanford (CA)	2401	6.0
Williams (MA)	507	6.0
Bryn Mawr (PA)	276	5.9
Earlham (IN)	308	5.9
Franklin & Marshall (PA)	554	5.9
Brown (RI)	1388	5.8
Radcliffe (MA)	469	5.8
New School (NY)	57	5.6
Stevens Institute (NJ)	359	5.6
Worcester Polytechnic (MA)	400	5.6

Ratio=average science Ph.D's divided by average baccalaureate degrees awarded.

Science Ph.D. totals reported by the National Academy of Sciences. Sciences include Empirical, Life, and Social Science fields.

Baccalaureate totals reported by the National Center for Educational Statistics and the American Council on Education.

Calculations based on Ph.D's conferred, 1951-1980, and bachelor's degrees awarded, 1946-1976.

(In a few cases, the numbers reported here differ from previously published numbers because of adjustments in baccalaureate data.)

STATEMENT OF

THE ENGINEERING EDUCATION TASK FORCE of:

THE NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

THE NATIONAL ASSOCIATION OF STATE UNIVERSITIES
AND LAND-GRANT COLLEGES

on the

FY'87 National Science Foundation Authorization

before the

Committee on Labor and Human Resources
U.S. Senate

March 26, 1986

Mr. Chairman and Members of the Subcommittee:

We appreciate this opportunity to share our views on the National Science Foundation authorization for FY'87. This statement is being submitted for the record by the Engineering Education Task Force, a multi-society task force convened in 1983 to bring together the resources of societies with mutual interests for the purpose of evaluating and developing legislative solutions to critical engineering education and research problems. The Task Force is chaired by Dr. Robert D. Kersten, P.E., Dean of Engineering at the University of Central Florida, who represents the National Society of Professional Engineers (NSPE). The other participating organizations are the American Society for Engineering Education (ASEE), including its Engineering Deans' Council, and the National Association of State Universities and Land-Grant Colleges (NASULGC).

NSPE is a non-technical professional society representing over 75,000 professional engineers of all disciplines nationwide, who are employed in industry, private practice, government, construction and education. ASEE represents over 10,000 engineers, primarily faculty, and over 250 accredited engineering schools, as well as more than 100 major engineering-oriented industries. Over 30% of all students enrolled in institutions of higher education attend the 144 NASULGC member colleges and universities, which include 24 of the nation's largest institutions and multi-campus systems of higher education.

In the current climate of intense fiscal austerity, we believe it is especially important to examine carefully all Federal expenditures in terms of their return on investment and the degree to which other sources of funding can be developed. From this perspective, the President's FY '87 budget request for the National Science Foundation clearly emerges as a vital insurance policy guarding our economic welfare and world leadership.

Unlike many areas of the budget, the National Science Foundation supports the development of resources that fuel economic growth. However, because the payoff from this investment in academic talent, training and research is only apparent in the long term, those unfamiliar with the Foundation's programs and accomplishments may not appreciate the critical role played by the NSF. Before looking at the specifics of the proposed budget, therefore, we would like to highlight this point.

It is often said that the National Science Foundation makes only a small contribution to the nation's research and technology base compared with the mission agencies. While it is true that other agencies fund a substantial amount of the nation's research, the largest share of that work is development, directed toward a specific commercial or military application. This type of support is focused on the final product, with the objective to advance the agency's primary mission. The next largest percentage of all federal R&D support is characterized as applied research, which again is geared toward a mission related result.

These forms of research support are not intended to advance the forefronts of knowledge, but to use the basic research results that already exist to benefit an agency's mission, such as defense. The smallest share of federal R&D expenditures is for basic research, which undergirds all other research and provides graduate students and faculty with opportunities to acquire sophisticated skills and knowledge. And the only agency in the federal structure responsible for advancing both people and research in this way is the National Science Foundation.

Again, though, an examination of the distribution of research funds by agency makes the NSF share of Federal funding of basic research, 16% under the proposed FY '87 budget, appear fairly insignificant. If only basic research performed at colleges and universities is considered, that share grows to 25%. In many areas, however, the unique role that the National Science Foundation plays is masked by these broad statistics.

This is especially true in engineering, where in several disciplines the NSF is almost solely responsible for both the research and talent addressing critical issues at the nation's colleges and universities. For example, in FY '84, the most recent year for which statistics are available, the NSF supported 74% of basic research in chemical engineering conducted at colleges and universities. In civil engineering, the figure rises to an astonishing 93%.

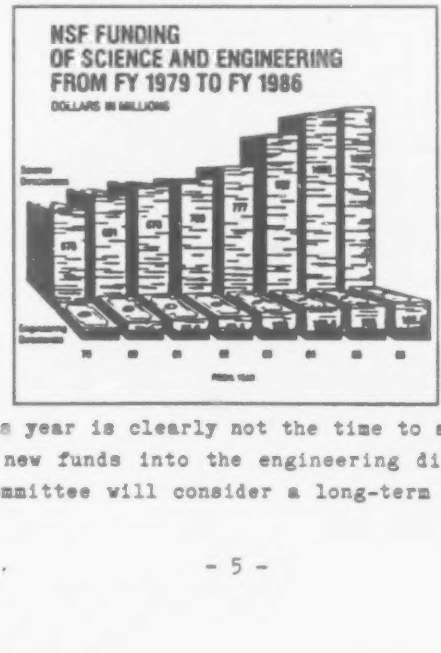
The reason why the NSF share is so high lies in the nature of the work, which is generic and therefore not of immediate interest to mission agencies or industry, but which has some potential for future application. For example, in the civil field, NSF is essentially the nation's only sponsor of fundamental engineering research in structural design, which generates more stress resistant methods for building bridges and other essential elements of the nation's public works infrastructure. This research is desperately needed; in past decades, and even today, these structures have been built using existing, though clearly outmoded, technologies. Without this most basic work, new methods will not come to fruition. And in many fields, particularly engineering, NSF funding serves to leverage non-federal resources, bringing the total investment in research and talent to a higher level than would otherwise be possible.

Clearly, the future growth of our nation depends on research in these and other critical engineering and scientific areas. With the National Science Foundation leading the way, advances in technology can help ensure a bright future.

Given that the National Science Foundation plays such a crucial and irreplaceable role in supporting the nation's academic foundation of research and talent in science and engineering, the need for stable funding becomes obvious. Neither research projects nor the researchers themselves can plan and perform high quality work without stable funding. To stop a research project midterm does not produce half of the expected results; it produces inconclusive, usually useless data. Rollercoaster funding for NSF does not just slow things down, it grinds the research and education enterprise to a halting stop, negating the valve of previous investments.

Therefore, while acknowledging that rapid growth of the NSF budget is not an option with the current fiscal crisis, we hope you and your colleagues throughout Congress will resist the temptation to reduce the proposed budget. The modest growth proposed allows advances in only the most pressing, promising areas such as biotechnology, the encouragement of more women and minorities to undertake science and engineering research and education challenges, and manufacturing processes. The budget request is both fiscally responsible and technologically exciting, no small feat considering the limitations imposed.

In engineering, the budget request is for $185.5 million, a 14% increase over the current plan for FY '86. Still, engineering accounts for only 14% of the total budget, a proportion that has not changed significantly over the last decade despite the growing importance of engineering to international technological competitiveness.


NSF FUNDING
OF SCIENCE AND ENGINEERING
FROM FY 1979 TO FY 1986
DOLLARS IN MILLIONS

While this year is clearly not the time to suggest a massive investment of new funds into the engineering directorate, we do hope the Subcommittee will consider a long-term growth plan that will allow the Foundation to respond better to critical needs in engineering education and research. Last fall, the National Academy of Engineering performed an analysis of the NSF's engineering programs. The final report, New Directions for Engineering in the National Science Foundation, concluded that "The maintenance of this country's technological leadership cannot be assured in the absence of engineering research at the cutting edge of knowledge. Because the process of technological innovation depends directly upon the quality and quantity of engineering talent...it is vital that NSF regard this national challenge as a challenge to itself as an agency and, more specifically, to its engineering directorate."

The report recommends that to meet current needs, the budget of the engineering directorate should grow to between $350 million and $410 million per year. We strongly endorse the Academy's recommendation, and urge you to approve the proposed budget with this goal in mind.

The need for more resources does not stem from a desire to just conduct more research. Rather, the engineering education enterprise is desperately in need of rather substantial improvements. In trying to honor demands for good research and talented people, engineering schools find themselves struggling to maintain superior standards in the face of a variety of problems:

* **Engineering faculty shortages** remain of paramount concern. Currently, one in twelve budgeted positions is vacant. As many as 23% more positions are needed to bring the student-faculty ratio close to optimum teaching conditions.

* **High enrollments** at the undergraduate level strain an already sparse faculty and poor facilities. While enrollments have grown over 115% over the last fifteen years, faculty growth has been approximately 10%.

* **High quality** of entering students masks the poor "value added" being provided by undergraduate engineering education. The majority of entering freshmen are in the top 10% of their graduating high school class.

* **Unattractiveness of faculty careers** is furthered by limited incentives for bright students to pursue graduate engineering education. Fellowship awards should be increased to equal at least one half of starting B.S. salaries.

* **Deteriorating physical plants** detract from the quality of instruction and research, and reduce the attractiveness of an academic career.

The American Society for Engineering Education is nearing completion of a two year project, sponsored by thirty major corporations, to develop a strategy for ensuring the excellence of the faculty and the academic working environment in coming years. The four task forces of the Quality of Engineering Education Project (QEEP) have produced interim reports with tentative recommendations for schools, faculty, government and professional societies. A copy of those reports are attached for the record.

In sum, we urge you to support fully the FY '87 National Science Foundation budget request. The NSF plays a vital and irreplacable role in maintaining and enhancing the technological and economic strength of our nation.

QEEP

Quality of Engineering Education Project

Introduction

Project Director: W. E. Lear

Before the two-year Engineering College Faculty Shortage Project was completed in September 1983, the ASEE Board of Directors discussed the need to continue the project. Surveys undertaken in connection with the project had documented the seriousness of the problems facing engineering schools. Board members agreed that the lack of adequate numbers of qualified faculty was still a critical issue but that the continuing effort should be broadened to include all factors that affect the quality of engineering education. This program was labeled the Quality of Engineering Education Project (QEEP).

A committee appointed by then-President John Hancock developed a comprehensive proposal, which outlined actions aimed at improving or restoring excellence in seven broad areas directly affecting the quality of engineering education. To seek advice on the proposed plan, the officers of the Society met in December 1983 with representatives of its industrial member companies and its government and association members. Convinced of the effort's merits but uncertain of how much could be tackled at once, the advisers suggested that since the faculty is the key to the quality of engineering programs, the project should concentrate on assuring the excellence of the faculty and the academic working environment in coming years.

> "The project concentrates on assuring the excellence of the faculty and the academic working environment in coming years."

With this background, the QEEP Advisory Committee proposed a two-year program aimed at: 1) ensuring that U.S. engineering education has the faculty required for excellence in the decades ahead, and 2) addressing two critical issues in the future working environment of the faculty—the use of educational technology and the role of the undergraduate engineering laboratory. The project was formally launched on September 1, 1984, with support from 25 (now 28) corporations. Four task forces of eight to ten people each were organized, with membership drawn from industry and academia. These are

- The Task Force on Preparation for Teaching of Engineering,*
- The Task Force on Continuing Professional Development of the Faculty,
- The Task Force on the Use of Educational Technology, and
- The Task Force on the Undergraduate Engineering Laboratory.

The project has an Advisory Board composed of one member from each sponsoring company plus seven academic members appointed by the ASEE President. Directing the QEEP project is the Executive Director of ASEE.

In September 1985, at the end of the project's first year, each task force prepared for the Advisory Board a report of its efforts, including tentative findings and recommendations. The reports are preliminary and do not necessarily cover all topics that will eventually be addressed, nor at this point do they all represent complete agreement among members of a particular task force on the findings and recommendations.

The summaries that follow are presented to make known to ASEE members and others the directions being taken by each group. *Readers are urged to send (or phone) their suggestions and criticisms regarding any part of these tentative results to individual task force members, to the task force chairmen or to the project director.* The summary reports have also been presented at recent meetings of several ASEE sections, at the ABET annual meeting and at the Frontiers in Education meeting for discussion and criticism. Each task force hopes through this feedback process to receive advice it can use in developing a final report for publication in the fall of 1986.

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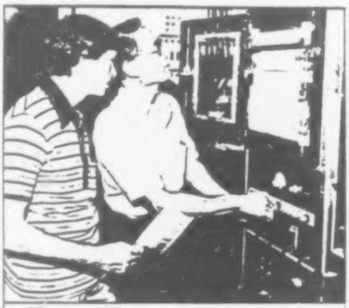
* The generic term "engineering" is intended to include engineering technology. Each task force addresses both engineering and engineering technology education.

QEEP
Quality of Engineering Education Project

Preparation for the Teaching of Engineering

Task Force Chairman: John D. Kemper



Charge: To examine the current modes of preparation of engineers for faculty positions, to determine the adequacy of that preparation for the present and future needs of the profession, and to recommend changes if indicated.

The Task Force on Preparation for the Teaching of Engineering found that although engineering education has been remarkably successful since World War II, there are some serious problems that require attention, principally in connection with the competitiveness of the United States in international markets. The Task Force believes that engineering is only one element—although a crucial one—relating to this problem. It believes engineering education can contribute to the strengthening of U.S. competitiveness by a greater educational emphasis on the totality of the process of developing and manufacturing high-quality, low-cost products. In particular, the Task Force feels it is wrong to emphasize only the "manufacturing" end of this process and recommends instead that the entire scope of the manufacturing process be enhanced in its visibility, and that research be seen as an integral first step in that process.

In examining the preparation of engineering professors, the Task Force found it necessary to back up and ask what it is that professors are expected to do. It was then necessary to back up another step and ask what it is that the professors' principal products—the graduates—are expected to do. Taking these in reverse order the Task Force's conclusions are summarized as follows.

Conclusions and Recommendations

Expectations

Most employers prefer that their graduates have a solid background in fundamentals, coupled with a certain level of skill in solving problems that have a real-world flavor. It is generally acknowledged that today's graduates have a good preparation in the basics but not as good a background in solving problems, principally because of recent heavy increases in student/faculty ratios but also because faculty members frequently lack direct experience in industry or other engineering practice.

With respect to faculty activities, these are generally grouped under the following headings: 1) teaching, 2) research or other creative activity, and 3) university and community service. The Task Force notes that different educational institutions will differ in their emphasis on these components, but that *teaching* is a special kind of function that distinguishes a university from, say, a research institute. Teaching is thus a primary function in a university or college, and effective teaching should be an essential criterion in appointment or advancement.

Teaching and Research

In a university with strong graduate programs, particularly at the doctoral level, effective performance in research will be held to be equal in importance to teaching, although universities usually make allowance for "engineering design" in this category, provided the designs are conceptually advanced and have significant impact on the field. Institutions with major doctoral programs will probably choose to emphasize published research papers as the principal evidence of creative activity; other institutions may include research as one form of creativity, but de-emphasize its importance with respect to other kinds of activity.

In the case of schools without doctoral programs, there would seem to be little reason to emphasize research as the principal form of creative activity, and a preference would exist for a broad mix of ways in which faculty creativity might be demonstrated. In this category, also, would be schools that offer bachelor's degrees and associate degrees in engineering technology, where forms of creativity other than research may actually be preferred.

Number of Doctorate-Granting Institutions

There were 149 universities offering doctoral programs in the United States in 1983. One-third of these schools produced more than three-fourths of the doctoral degrees. These schools are thus the principal sources of engineering faculty. Nearly half of the doctorate-granting schools awarded fewer than 10 doctorates each in 1983. Our existing system of engineering graduate schools is thus capable of expanding its production to meet any foreseeable need for engineering faculty, and the startup of additional Ph.D. programs is not encouraged.

Ph.D. Requirement for Faculty

At universities that emphasize research and graduate study, the great majority of the engineering faculty should possess doctoral degrees, although it is reasonable that some faculty with unusual accomplishments might be appropriately employed even if they do not hold the doctorate. Extensive industrial experience might in some cases substitute for possession of the Ph.D. In colleges and universities that emphasize undergraduate study, such strong reliance on the doctorate should not be necessary, particularly if the institution itself does not offer a doctoral degree. Greater reliance may then be placed on other forms of accomplishment such as industrial experience, although it seems appropriate for a large share of the faculty to possess doctorates. For institutions offering engineering technology programs at the bachelor's and associate degree levels, the Ph.D. is not a justifiable requirement for faculty status.

Teaching Assistants

There has been much concern that our system does not encourage enough of our best students to seek careers in education. Further, about 44 percent of all engineering teaching assistants are foreign nationals, many of whom are reported to have inadequate English skills. Accordingly, the Task Force recommends that the following steps be taken to improve the quality of those who are attracted into teaching asistant positions, and thus to improve the future quality of the engineering faculty.

- Universities and colleges need to take steps to make engineering faculty positions more attractive and prestigious in order that more of our best-qualified U.S. students will wish to enter a system that leads to a faculty appointment.
- Universities need to make graduate teaching assistant positions more attractive by providing a professional working environment for T.A.'s. This might include providing recognition for outstanding T.A.'s, providing suitable office space, equipment and support, and providing computer services. Stipends for teaching assistants should be increased to a level of at least half the current starting salaries of B.S.-level engineers.

> "Teaching assistants for
> whom English is a second language
> should be required to pass
> the ETS Test of Spoken English
> at an acceptably high level."

- Since experience as a teaching assistant is virtually the only training that prospective faculty members receive for their future careers, the experience should be treated as a more structured learning experience than now seems to be the case. Specific orientation courses should be devised for new T.A.'s, and their activities should be supervised by experienced faculty members, with opportunities for feedback and evaluation.
- Teaching assistants for whom English is a second language should be required to pass the Test of Spoken English administered by the Educational Testing Service, at an acceptably high level. A score of 250 (out of 300) is recommended as a minimum pass level.

Relevance

An aspect of engineering education that receives too little attention in today's crowded curricula is that which imparts an understanding of the international, product-oriented climate in which modern engineers must operate. These include such factors as: satisfying the customer; designing for quality, reliability, safety, cost and manufacturability; satisfying societal needs such as conserving scarce resources and preserving the environment; effective communication; ethical action. Faculty must pass on to their students the problems and limitations of real life. An immersion in meaningful industrial problems will give engineering faculty this additional orientation, supplementing their valuable knowledge of engineering science. We recommend:

- Engineering schools of all types should seek to employ the highest percentage possible of faculty with industrial experience. This applies to research universities as well as others. With the increasing tendency of industry to lead academia in some research fields, and with the increasing tendency for industry to employ engineers with graduate degrees, the need for close relationships between industry and academia becomes stronger than ever.

> "For institutions offering engineering technology programs at the bachelor's and associate degree levels, the Ph.D. is not a justifiable requirement for faculty status."

Specifically, we recommend that all engineering faculty be expected to have accumulated at least two years of experience in industry or in private practice. This experience may be gained through a series of summer jobs, through consulting, by supervising industrially-sponsored research contracts, or some combination of these. It need not all consist of pre-employment experience, but might mutually be understood to be achieved before the granting of tenure. Familiarity with industry should be kept current through consulting, summer employment and joint industry/university research programs.

- Cooperative education programs have great educational value for students because they help provide motivation and direction. They should be expanded to the greatest possible degree, while maintaining high quality. To be of maximum value, they need to be sustained through good times and bad, and not be allowed to wax and wane with economic cycles.

Competent Teaching

Engineering professors must not only be competent technically but must also be effective teachers.

- All persons preparing to teach engineering (the pre-tenure years) should be required to include in their preparation studies relating to the practice of teaching. It should be the responsibility of the hiring institution to provide guidance and assistance in this aspect of faculty preparation by recommending and sponsoring appropriate seminars, workshops and institutes.

- As a minimum, educational institutions should offer a pre-service workshop or seminar for new faculty members, perhaps involving one week for which extra pay is given, to cover such things as: institutional goals and expectations, course organization and development, examinations and grading, student performance, student/teacher interactions and the like. Annual professional development reviews with academic administrators should include discussion of the candidate's progress and growth in teaching.

Reaching Women and Minorities

To achieve the goal of increasing the proportion of women and under-represented minorities on engineering faculties, efforts must be applied across the board, and especially at the high school and junior high school levels, to reduce the effects of economic, educational and cultural factors that now turn members of such groups away from engineering. Major efforts are needed with respect to minority groups at the precollege years, and upgraded retention programs are needed at the college level. Efforts must be made to eliminate discrimination, real or perceived.

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QEEP
Quality of Engineering Education Project

Continuing Professional Development of Engineering Faculty

Task Force Chairman: Robert M. Anderson

The extremely rapid rate of change in the knowledge base for engineering education makes the engineering educator's task of keeping up to date more difficult than ever. The Task Force on Continuing Professional Development of Engineering Faculty was charged with the responsibility for examining the problem and developing recommendations for action.

Continuing professional development is a process by which professionals enhance their competence in their profession. To address the professional development of engineering faculty, the Task Force begins with an examination of faculty responsibilities. Next it identifies critical issues that demonstrate how continuing professional development is an important problem for engineering faculty members, one that requires special attention and the dedication of significant resources. An examination of current approaches to engineering faculty development reveals their inadequacy to meet today's needs. The Task Force offers a vision of an effective system and identifies groups that have primary, secondary and supportive responsibility for that system. Finally, it offers specific action-oriented recommendations to each group.

Charge: To study the present system of faculty development in the engineering colleges of the nation and to recommend ways the colleges can develop a systematic approach to ensuring technical and pedagogical currency of each faculty member throughout his or her career.

Responsibilities of Engineering Faculty

The Task Force has defined three broad areas of faculty responsibility:

1) The creation and acquisition of knowledge,
2) The dissemination of knowledge, and
3) Professional and public service,

and examines them in detail. The resulting picture is that of a complex situation in which the faculty member is expected to be at the cutting edge of a technical specialty, knowledgeable about related specialties and able to change fields as appropriate, and an effective classroom teacher conversant with the best in pedagogy—all while being actively involved in professional and public service.

This examination of responsibilities and expectations points up the difficulties faced by engineering faculty members who wish to stay current in their many-faceted jobs. A question that may be logically posed, however, is: What is critical about the situation today as opposed to any time in the past?

In answer to the question two critical issues are identified which threaten the continuing competence of engineering faculty and put at risk the continuing supply of top-quality engineering graduates to meet the nation's needs. These two issues are a galloping rate of technological change and a parallel demand that faculty review seriously the educational processes used to produce engineers. The Task Force has concluded that in today's world the continuing professional development of engineering faculty cannot be left to chance.

Current Approaches and Effective Faculty Development

A critical review of the current situation with regard to faculty development in engineering schools has yielded a catalog of activities through which faculty pursue continuing professional development. The Task Force concludes that in most institutions faculty development is pursued on an ad hoc basis with little or no purposeful planning.

It further concludes that the primary missing ingredient in our reaching the goal of providing each faculty member the opportunity to stay current is a deliberate professional development plan for each engineering college. Such a plan includes not only the types of activity in which faculty members will engage but also an assessment of the resources needed to support that activity.

> "The primary missing ingredient is a deliberate professional development plan for each engineering college."

Although the fraction of the engineering college budget required for an effective faculty development plan will vary considerably among institutions, each school should begin now to ensure that appropriate resources are regularly allocated to support faculty development activities. If significant amounts of time and money are to be allocated, we can no longer tolerate an undisciplined, ad hoc approach. Purposeful planning by both individuals and institutions is in order.

Responsibilities and Recommendations

Responsibility for engineering faculty development is divided into two major parts. The following have *primary* responsibilities:

Individual Engineering Faculty Members

Faculty members must be primarily responsible for maintaining their own professional competence. Only they know what skills and knowledge they lack. They must have the professional pride and commitment necessary to keeping professionally competent.

- The most important recommendation is that individual engineering faculty members assume primary responsibility for managing their own professional development and that they actively plan and execute their own program.

Engineering College Administration

The college administration bears the responsibility for providing the supportive framework within which each faculty member can be expected to carry out a regular program of continuing professional development. Individual faculty members cannot discharge their primary responsibility without adequate institutional support. An investment of money and attention in professional development should make faculty recruitment easier and should improve teaching and research, which in turn will attract better students and more public and private funding.

- Deans and department chairmen must take the lead in developing and implementing a program for the college under which continuing professional development is a regular part of each faculty member's job. This commitment includes developing the necessary budgetary resources.

University Central Administration

The university administration must also be proactive in recognizing the special resource needs of a good engineering program. In the current climate of increased university/industry partnership it is important that engineering programs, which are of special interest to industry, be maintained at a high level of quality.

- The president and chief academic officer of the university should provide the budgetary support required by the engineering college for an ongoing program of faculty professional development. They must recognize that the engineering disciplines have a particularly fast-changing knowledge base and that engineering faculty need extra institutional support to maintain their competence.

Many groups have a strong interest in maintaining the professional competence of the engineering faculty. Rather than having a primary responsibility to act directly, the following groups have a *secondary* responsibility for aiding and supporting both individual faculty members and their institutions:

Government

Government at all levels has a stake in ensuring that the engineering faculty—the group largely responsible for the competence of the engineering workforce—maintains its own competence. Not only is government a major employer of engineers, but both regional and national governments are responsible for promoting economic growth, the effect on that growth of well-educated engineers and strong engineering colleges is well documented. And only a highly competent engineering faculty can perform the fundamental engineering research so essential to society's future.

- To help engineering faculty and administrators develop comprehensive, ongoing plans of professional development for every faculty member, the National Science Foundation should fund several experiments in the design and implementation of such plans. If undertaken in a variety of institutions, these experiments could produce models on which all types of institutions can draw.
- As an employer, government at all levels should assume a leading role increasing opportunities for meaningful summer and sabbatical assignments for faculty.
- The federal government should ensure that the income tax exclusion now provided for employees who receive tuition support from their employers is not lost. Without the exclusion, a faculty member could be penalized for pursuing some forms of professional development.

Professional Societies

Engineering and professional societies have the charter to preserve and advance the state-of-the-art in specific disciplines. As important contributors to that process, engineering faculty value the common forum that professional society meetings provide to professors and practitioners.

- Professional societies should offer regular, tutorial, state-of-the-art courses specifically for engineering faculty members in conjunction with more traditional society meetings and during the summer.
- Professional societies should also develop "matchmaking" programs to help professors find appropriate developmental employment in their discipline during summers and for sabbatical leaves.

Employers of Engineers

Employers depend on being able to hire capable new engineering graduates and on keeping their workforce technologically current. A capable faculty is necessary to produce capable graduates and can help to keep the existing workforce up to date.

- Employer organizations should make a special effort to provide developmental work assignments to engineering faculty during summer and sabbatical leaves. Industry can make some of its specialized facilities—and employees—available to students and faculty to help both gain experience and competence with modern engineering equipment.

Accreditation Board for Engineering and Technology (ABET)

ABET is constituted to promote and advance engineering education to further the public welfare. Through the accreditation process, ABET exerts considerable influence on U.S. engineering education.

> "Each school should begin now to ensure that appropriate resources are regularly allocated to support faculty development activities."

- A thorough review by ABET of accreditation criteria as they relate to faculty competence and development is in order. Although current criteria list a variety of factors by which faculty competence may be judged, the extent to which that judgment is made in practice is subjective and not well understood. Current criteria say almost nothing about faculty members keeping up with new developments. ABET's Engineering Accreditation Committee should undertake to write more quantitative standards for faculty development activities and to use the expanded criteria in their accreditation processes (e.g., self-study, visits, reports). If this change were made, within a decade significant progress in faculty development could be felt in every U.S. engineering program.

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QEEP
Quality of Engineering Education Project

The Use of Educational Technology

Task Force Chairman: Russel C. Jones

The Task Force on the Use of Educational Technology has undertaken a study of the driving forces behind the use of educational technology, previous efforts in applying educational technology, current major issues from a variety of perspectives, and the current technology base available for use.

Charge: To identify the technology now available for potential use in improving the efficiency and currency of engineering education, to study the problems and promise of experiments underway in engineering colleges in the use of such technology, and to recommend a viable approach toward integrating appropriate technology into the engineering education process of the nation over the next decade.

Driving Forces and Previous Studies

Of the many changes in engineering practice in recent decades, the most dramatic has probably been the introduction of the electronic computer. The rapid rate of technological change and greatly enhanced communications also strongly affect the way engineering students should be prepared for practice. In an effort to make the educational process more effective, and in particular more cost-effective, simulation is seen as an alternative to costly laboratory equipment. The need to make continuing education more accessible further encourages the use of educational technology.

In reviewing previous studies and how various technologies have been applied to engineering education and related fields, the Task Force hopes to provide objective evaluations and a background from which engineering schools can consider currently available technologies.

Major Issues and Current Technology

The problems and promise associated with the use of educational technology are being explored through an examination of the major issues related to students, faculty, graduates, curriculum and logistics. Among the items under study are:

- How to define computer literacy for the engineering graduate;
- The slow pace at which curricula change to incorporate new technology;
- How extensively advanced technologies are being used in upper-division courses;
- The need to develop an appropriate reward system for faculty involved in developing and using educational technology;
- Distributed delivery of continuing engineering education;
- Portability of software and courseware; and
- Institutional costs of using educational technology.

A review of the current state-of-the-art and future directions of four technologies—computers, video, print and communications—makes clear that engineering educators must act now to prepare for the academic environment they desire in the decades ahead.

Goals and Recommendations

In response to the charge of the Task Force, it seems appropriate to list first a set of overall goals for the desired impact of educational technology in engineerng education, then to develop a set of specific recommendations on how to meet those goals.

The following are the overall *goals* proposed by the Task Force:

- The links between practice and education need to be substantially strengthened.
- Engineering education must be a lifelong process in order to keep graduates current once out in practice.
- Engineering curricula need more design content, in general, and correspondingly less detailed coverage of analysis.
- Engineering faculty (not just education faculty) need to work toward educational enhancement.
- The effectiveness and efficiency of engineering education must be improved.
- The diversity of experiences available to students needs to be increased, in order to broaden and deepen the educational experience.
- Continued faculty growth and development must be nurtured.
- Mechanisms to develop and distribute software and courseware, parallel to those available in the textbook field, need to be established.
- Hardware, software and courseware must be standardized to allow portability among academic units.

These goals can be fleshed out through the examination of specific *recommendations* to each of several constituencies in engineering education. The following subsections list recommendations for such groups.

Engineering Faculty

Engineering faculty members, individually and collectively, should take the following actions:

- Take leadership roles on campus in developing and applying appropriate educational technologies.
- Share software and courseware freely both on campus and throughout engineering education, minimizing intellectual property rights barriers.
- Work with university administrations to develop appropriate intellectual property rights policies and procedures, with equitable reward structures for both faculty members and universities, while keeping the products affordable to the consumer.
- Be innovative in updating the engineering curriculum to use the latest technologies effectively.
- Get involved in the off-campus delivery of continuing education, using educational technology as appropriate.
- Assist in developing methodologies for advanced educational delivery systems.
- Place a high priority on developing and using modern instructional methods and using educational technology to prepare engineering students adequately in design.

University Administration

The administrations of universities with engineering schools should:

- Develop strategic plans for necessary and appropriate allocation of resources to develop educational technologies (perhaps on the same order of magnitude as currently allocated to the library system).
- Recognize and reward faculty members who develop software, courseware and systems to allow appropriate and effective use of educational technologies—including the ultimate rewards of promotion, salary raises and tenure.
- Develop mechanisms for the *distributed* funding of developments in educational technology, recognizing that the traditional centrally-funded academic computing center seldom provides a hospitable locus for such activities.
- Provide stimuli to promote the upgrading of faculty members in the use of modern educational technology (training, sabbatical opportunities, seed funds, etc.).
- Work with faculty to develop procedures whereby those who develop software and courseware can equitably share in the financial returns they generate.

> "The administration should recognize and reward faculty members who develop software, courseware and systems to allow appropriate and effective use of educational technologies."

Technology Vendors

The manufacturers of advanced delivery products intended for use in engineering education should:

- Strive to deliver more capability and higher quality products, at the lowest possible prices and requiring as little maintenance as possible.
- Move rapidly toward industry-wide standardization of hardware and operating systems.
- Develop reasonable cost approaches to site licensing on campus.

- Make equipment grants (with support services) to engineering schools willing to use advanced delivery systems and develop courseware for them—including schools that have not traditionally been leaders in such use.

> "Technology vendors should move rapidly toward industry-wide standardization of hardware and operating systems."

- Provide exchange programs for faculty members and corporate leaders, including sabbaticals in both directions, for those interested in educational technology.
- Develop educational efforts to bring engineering faculty members up to speed in the use of advanced educational technologies.

Accreditation and Professional Societies

The several engineering societies concerned with engineering education in their particular technical fields, the Accreditation Board for Engineering and Technology, and the American Society for Engineering Education should:

- Ensure that engineering students are adequately exposed to the use of appropriate educational technologies, both to provide better initial engineering education and to promote more effective use of such technologies in lifelong learning.
- Give appropriate coverage to developments in educational technologies in society publications, seminars and conferences, and award programs.
- Develop and promulgate appropriate accreditation standards concerning desirable use of such technologies in engineering education.

Government Bodies

The several government bodies concerned with engineering education, including the National Science Foundation and the federal mission-oriented agencies, should:

- Take a leading role in promoting the appropriate development and use of educational technologies, through attractive funding programs.
- Promote the establishment of tax credits and other incentives for equipment contributions and the funding of research and development in the educational technology area.
- Provide mechanisms for the dissemination of results of educational technology research (publications, conferences, short courses, etc.).
- In collaboration with state agencies, provide funding sources to develop educational technology systems throughout U.S. engineering schools.

Corporate Employers

Those organizations that employ graduate engineers, and rely on engineering schools to assist in their continuing education, should:

- Take positive steps to promote and support the use of appropriate educational technologies in both the original engineering education and in lifelong learning.
- Insist that engineering schools graduate students adequately prepared to work in design and/or manufacturing in the modern computationally-oriented world of practice.
- Assist schools in obtaining modern technologically-oriented equipment for classrooms and laboratories.

Task Force on Use of Educational Technology

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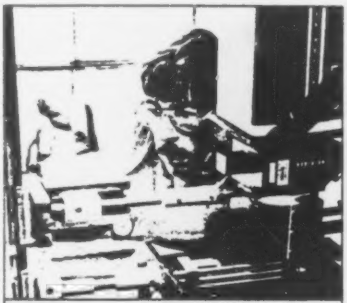
QEEP

Quality of Engineering Education Project

The Undergraduate Engineering Laboratory

Task Force Chairman: Edward W. Ernst

As part of its efforts, the Task Force on the Undergraduate Engineering Laboratory distributed questionnaires asking for information and opinions related to the laboratory-oriented portions of engineering and engineering technology programs. These questionnaires were distributed to selected academic institutions that offer programs in engineering and engineering technology, industrial organizations that employ graduates of these programs, and engineering professional societies. The responses have corroborated the Task Force's understanding in some cases and offered new insights in others. In general, the responses demonstrate a significant interest in engineering laboratory studies in both academia and industry.



Charge: To study the current role of laboratory instruction in engineering education, to assess its future role, and to develop recommendations on means for ensuring the full partnership of laboratory instruction in the engineering education process.

This interim report is divided into findings and recommendations.

Findings

These statements about the undergraduate engineering laboratory are drawn from the deliberations of the Task Force and the responses to the questionnaire.

Educational Value

1) The laboratory segment is a valuable part of an engineering or engineering technology education. This view comes from those in academic institutions *and* those in industry. For some, laboratory experience is *the* facet that sets these programs apart from other educational programs at the same academic levels.

Objectives

2) Although many functions and roles for the undergraduate engineering laboratory are described, the primary objectives for the laboratory portion of an engineering education may be stated as:

a) The student should learn to do experimental work. This includes planning the experimental work, conducting the experiment and analyzing the results.

b) Laboratory work should serve to reinforce the concepts presented in other parts of the educational program. The impact on the student of observing the physical phenomena described in texts and other literature, as well as that presented in lectures, is significant and enhances the learning process.

c) The laboratory portion of the program provides an opportunity to develop the student's ability to communicate effectively. Although many parts of the engineering program may provide opportunities to develop communication skills, the laboratory is believed to provide an opportunity that is more appropriate than most for developing the kinds of communication skills required in engineering practice. The experiments conducted by students constitute engineering information that the student has participated in creating; communication of this information to others requires skills similar to those needed by engineers in communicating results of engineering work to supervisors or other interested parties.

The questionnaires indicate that objective (a) is clearly accepted by all groups as a primary objective. Objective (b) appears to be secondary for those in academia, while objective (c) is clearly secondary for those in industry.

3) Although the competence of recent graduates for experimental tasks appears acceptable, further on-the-job training is required. In general, the associate degree and baccalaureate engineering technology graduates appear better prepared for the experimental tasks expected of them than do graduates of engineering programs. Some graduates of baccalaureate engineering programs require considerable added training before they can undertake the experimental work expected of them.

4) The associate degree engineering technology graduates are expected to have experimental capability that extends beyond the particular disciplinary specialty to a greater degree than do graduates at the baccalaureate level. However, there appears to be a universal need for engineering graduates in all disciplines to have experimental competence that includes electronics and the use of the computer for experimental work.

5) There are two primary obstacles to excellent undergraduate engineering laboratory programs. The one mentioned most frequently is the lack of appropriate kinds and adequate amounts of equipment. Included here is the lack of adequate resources for maintaining equipment and the lack of adequate, appropriately-equipped space for instructional laboratories. The second obstacle is the lack of participation in laboratory instruction by engineering faculty. The relatively low level of faculty involvement appears to result from the lack of recognition and reward for such faculty efforts.

6) Although nontraditional approaches to laboratory instruction are considered by many to be valuable ways for strengthening the program of laboratory instruction, there appears to be little, if any, support for replacing traditional hands-on laboratory experience with other approaches.

Recommendations

Encouraging Cooperation with Industry and Government

- The value of laboratory-oriented instruction as an essential part of an engineering or engineering technology education must continue to be affirmed by industry and the engineering societies, as well as the academic institutions offering programs in engineering and engineering technology. This affirmation must be expressed in the curriculum, in the allocation of resources and the in the faculty reward system. Industry must make more clear to faculty, administrators and students its interest in and concern for an excellent laboratory program.
- Engineering colleges should take the initiative to establish vehicles for interaction with industry that focus specifically on the mutual need for excellence in laboratory instruction and that provide a forum for identifying ways in which each can contribute to overcoming barriers to excellence.
- Significantly increased levels of support are needed for new laboratory equipment, the ongoing maintenance of the equipment and its replacement. In addition to the usual institutional sources of funding, other sources, including federal and state grants and gifts from industry, must be explored to provide the continuity of resources needed to prevent a recurrence of the current equipment-obsolescence crisis. More attention is required on the part of both academic institutions and industry to ensure that equipment donated by industry is appropriate and effective in improving the quality of the undergraduate laboratory experience.
- Active and vigorous representation to institutional governing and funding bodies on the part of industry and other employer organizations is required to encourage adequate funding of the undergraduate laboratory program.
- The federal government should support, through the National Science Foundation, the development of innovative approaches to laboratory-oriented studies for engineering students. These could include the use of simulation, computer-aided measurement and experi-

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mentation, and the use of modern educational technology.

Industry Experience for Faculty and Students

- Industry should provide internship opportunities for faculty to learn about current industrial laboratory practice. Adjunct faculty from industry can bring industry experience to the laboratory for both direct instruction and course development.
- Industrial organizations are encouraged to work with academic institutions to provide more opportunities for co-op and summer internship experiences that will enhance and supplement students' on-campus laboratory experiences.

Faculty Support and Recognition

- The time required of faculty to teach laboratory courses should not be significantly greater per teaching-credit-hour than that expected for teaching in other modes. Although this recommendation is primarily directed to academic institutions, support from industry and professional societies through the Accreditation Board for Engineering and Technology is needed to encourage faculty participation in laboratory instruction.
- Greater consideration should be given to the use of adequate numbers of qualified personnel to support faculty in laboratory instruction. These support persons include technicians and academic professionals.
- The requirements for faculty promotion and tenure should encourage young faculty members to participate in laboratory instruction. Faculty members who demonstrate unusual competence and ability in such instruction should be recognized and rewarded to the same extent as those whose competence lies in other areas.

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Statement of the Society for American Archaeology
Presented to the Senate Labor and Human Resources Committee

March 19, 1986

Mr. Chairman and Members of the Committee, the Society for American Archaeology is pleased to have the opportunity to present this testimony to you on behalf of the National Science Foundation.

The National Science Foundation's Role In Archaeological Research

The National Science Foundation has played a crucial role in archaeological research and development, and has made great impact in both public and academic realms. Through its use in a variety of publications, television and radio shows, and interpretative programs at archaeological sites, National Science Foundation funded work serves to address our nations's fascination with what archaeology can teach us about our history and prehistory. Further, through advances in scientific analysis of artifacts for dating and other purposes (archaeometry), National Science Foundation funded research results are being utilized by federal employees and contractors to increase the efficiency of archaeological inventory and research taking place on federal lands and in association with other federal undertakings. Accordingly, the Society for American Archaeology urges you to support the Administration's FY 1987 budget proposal.

Basic Research and Spin-off Benefits

Basic archaeological research can have significant spin-off benefits. For example, prior archaeolgical work has fostered the rediscovery of long forgotten prehistoric plants and resources which have contemporary practical applications. Obsidian glass, used for a variety of prehistoric tools, has been used successfully as surgical blades in delicate eye, heart, lung and nerve surgery. Obsidian surgical incisions promote a rate of post-surgical recovery time half that of contemporary surgical scalpel incisions. Research on two prehistoric seed bearing plants, Amaranth and Chenopodium, is being conducted in Utah, Illinois, Iowa and many other states. Both of these ancient plants provide a complete source of protein as well as high levels of calcium, iron and other essential vitamins, offering valuable potential as worldwide food sources.

SOCIETY FOR AMERICAN ARCHAEOLOGY

Archaeological sites provide evidence of the impact of human activities resulting in erosion, sedimentation, soil disturbance, depletion, and enrichment. These types of studies can serve as a means of addressing modern soil management programs. Information on rainfall and waterflow fluctuations from the archaeological record can aid planners in designing water-retarding structures that will adequately retain floodwaters.

Research Opportunities

There is a great opportunity for research due to the wealth of new data which has been collected by other federal agencies in the course of compliance with the National Historic Preservation Act and other federal laws. Since this new data is already available, it is time to integrate it into efforts to address existing research questions and to stimulate theory building. Further, study of this data is likely to lead to additional spin-off benefits. The Society for American Archaeology believes that a series of NSF funded projects focusing on regional integration studies is one way to maximize the public and scholarly benefits which can be gained from this data. There are, of course, other projects which could also make significant contributions.

The Administration's budget request for FY 1987 at NSF would enable continuation of existing programs as well as a modest archaeology initiative on regional studies in FY 1987.

Thank you for this opportunity to present this statement in support of increased funding and basic research possibilities at the National Science Foundation.

WRITTEN TESTIMONY

SUBMITTED TO

THE COMMITTEE ON LABOR AND HUMAN RESOURCES
OF THE
UNITED STATES SENATE

APRIL 18, 1986

SUBMITTED BY
THE JOINT POLICY BOARD FOR MATHEMATICS
1529 18TH STREET, N.W.
WASHINGTON, D.C. 20036

TESTIMONY ON THE FISCAL YEAR 1987 AUTHORIZATION FOR THE NATIONAL SCIENCE FOUNDATION

The Joint Policy Board for Mathematics (JPBM) is pleased to present written testimony to the Committee on Labor and Human Resources of the United States Senate on the fiscal year 1987 authorization for the National Science Foundation.

The Joint Policy Board for Mathematics is an executive policy board of the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics, professional associations representing the mathematical research, undergraduate teaching, and industrial and applied mathematics communities. The combined membership of these three organizations is 31,000, and includes most of the active mathematicians in this country. The Joint Policy Board works closely with the Conference Board of the Mathematical Sciences (CBMS), which represents all sectors of the mathematical sciences community [1].

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1. The mathematical sciences community comprises thirteen professional mathematical associations, whose presidents regularly meet under the auspices of the Conference Board of the Mathematical Sciences to discuss policy goals and options.

These organizations are: American Mathematical Association of Two-Year Colleges, American Mathematical Society, American Statistical Association, Association for Symbolic Logic, Association for Women in Mathematics, Institute of Mathematical Statistics, Mathematical Association of America, National Council of Supervisors of Mathematics, National Council of Teachers of Mathematics, Operations Research Society of America, Society of Actuaries, Society for Industrial and Applied Mathematics, The Institute of Management Sciences.

The Labor and Human Resources Committee is now reviewing the fiscal year 1987 authorization of the National Science Foundation (NSF). Over 50% of the total federal support for mathematics research comes from the National Science Foundation, as does a significant percentage of support for innovation in mathematics education. Therefore, it is fitting that the mathematics community takes this opportunity to present its concerns and recommendations on federal support for mathematics.

MATHEMATICS AS A FOUNDATION DISCIPLINE

Mathematics is the foundation discipline that makes progress in most fields of science and technology possible. This foundational role derives from two facts: (1) mathematics is the science of order--whether that order governs quantity, shape, arrangement, or form; and (2) the real world is the very epitome of a complex situation in which a great deal of order can be seen, if one has appropriate concepts for describing that order. The unique role of mathematics in science, technology and society more broadly is played through both education and research.

Over 25 million young people study mathematics every weekday in the nation's elementary and secondary schools. This is principally because:

- Mathematics is an important part of the preparation for functioning as an adult in our society, so much so that mathematics education begins in the first grade and continues systematically into the secondary level;

- High school and early college mathematics form an essential part of education for any of a broad spectrum of technical careers, and are necessary for the rudimentary grasp of science needed by all college graduates.

It is not widely appreciated that, for most of the theoretical aspects of science and engineering, mathematics is the very language in which the theory is described. The noted physicist, Richard Feynman, has said that one who would understand nature must be conversant with the language in which nature speaks to us. He had in mind mathematics, the language of order.

Those who would be scientists, engineers, mathematicians, computer scientists, economists, or the like, must understand theory and therefore must study mathematics through most of their collegiate years:

o Advanced college mathematics is an essential part of the basis for becoming a scientist or engineer in today's world; for would-be theoretical scientists, mathematics education continues into graduate school.

But the idea of a language necessary for describing things conveys only part of the picture, as does the idea of a foundation based on learning known mathematical methods.

There is an equally important, yet far less visible, way in which mathematics is a foundation discipline. It is this: Progress in science and technology depends in an essential way on the continual discovery of new mathematics. That is, such progress depends on the continued vitality of research in the mathematical sciences [2]. This is seen, for example, in the frequency with which Nobel prizes are awarded to scientists for work which depended heavily on sophisticated mathematical concepts and methods discovered only a few years before [3]:

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[2] The "mathematical sciences" research community includes: pure mathematicians, who create the discipline itself; applied mathematicians, who develop mathematical tools, techniques and models to understand scientific phenomena or solve basic technological problems; statisticians, who develop and apply mathematical techniques to analyze and interpret data for use in inference, prediction, and decision-making; mathematicians in operations research who develop and apply optimization techniques to management and decision-making; mathematical specialists in fields of engineering (e.g., communication and control theories); and mathematical biologists, mathematical economists, and others.

Computer science has a significant intellectual overlap with the mathematical sciences. However, it is not now included in discussions of funding support for the mathematical sciences because it has its own sources of funding.

- The products of mathematical research form the foundation on which science and technology advance--it is a living foundation, one which grows hand-in-hand with science and technology.

The National Science Foundation supports both mathematics education and mathematics research. Therefore, the condition and needs of both are addressed in this testimony.

I. MATHEMATICS EDUCATION

Mathematics is necessary for all citizens who will live and work in the twenty-first century. Mathematics is both an enabling force and a critical filter for careers in science and engineering. Without quality education in mathematics, we cannot build programs in science and engineering. The National Science Foundation policy for science and engineering education -- both precollegiate and collegiate -- must be built on this central fact: Mathematics is not just one of the sciences, but is the foundation for science and engineering.

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3. It is not a coincidence that the two most recent recipients of the Nobel Prize in chemistry are members of the American Mathematical Society.

A. ELEMENTARY AND SECONDARY MATHEMATICS EDUCATION

The crisis in mathematics and science education at the elementary and secondary level has been well documented in the past few years. Local, state and federal surveys report alarming statistics indicating that American student achievement in mathematics lags behind their international counterparts beginning early in elementary school and continuing into the undergraduate level.

This shortfall in student growth in mathematics points to an overall unpreparedness of our society to deal with the inevitable changes that increased technology in the work place will bring. It may seriously handicap our future natural and physical scientists, engineers, computer scientists, industrial technologists, economists, statisticians, and others dealing with quantitative information.

The mathematics research community joins with the mathematics education community to express concern about this grave situation. The mathematical sciences community acknowledges the importance the Congress places on quality mathematics and science education. With the passage of the Education for Economic Security Act has come increased opportunity for targeting the problems that erode quality mathematics education.

A NEW INITIATIVE IN EDUCATION

The whole of the mathematical sciences community, through the Conference Board of the Mathematical Sciences, has exercised leadership to complement the Congressional action taken in this area. In the spring of 1985, a proposal was submitted to the National Research Council [4] urging the establishment of the Mathematical Sciences Education Board (MSEB). The National Research Council has since adopted the proposal and established the Board.

Members of the Senate Labor and Human Resources Committee may find the Mathematical Sciences Education Board to be an exciting new development on the elementary and secondary education horizon, for several reasons.

First, the MSEB is an excellent example of partnerships involving not only educators at all levels (i.e., classroom teachers, school administrators, undergraduate instructors, and research mathematicians), but also parents, business and industry, and government at all levels (i.e., local, state, and federal). The thirty-four member Board broadly represents each of these sectors [5].

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[4] The National Research Council is the principal operating arm of the National Academy of Sciences and the National Academy of Engineering in Washington, D.C.

[5] See Appendix I for an annotated membership list of the Mathematical Sciences Education Board.

Second, the primary purpose of the MSEB is to provide a continuing national overview and assessment capability for mathematics education. This will be done through projects and activities of Board task forces, to which experienced educators and representatives from other sectors of the Board's membership will be appointed.

Third, and perhaps most important, is the answer to why a Board is needed. The educational reform movement of the post-Sputnik era was far less helpful than it might have been. Millions of dollars were spent to improve mathematics and science education. But the stop-gap nature of these efforts meant that once the first level of the problem was dealt with, both public and financial support began to wane.

The Board is designed to provide a continuing capability to support mathematics education well into the next century. The evolution of education--particularly mathematics education, which must change to prepare students to live and work in a high-technology society--must be viewed as a continuing process. Our rapidly evolving society will always have education problems. The Board is committed to providing a substantive overview of progress and problems in mathematics education and to continuously injecting the best ideas into the system.

BOARD ACTIVITIES

Since the appointment of members by the National Research Council last August [1985], two meetings of the full Board have been held, and an initial agenda has been established covering the following critical areas: influence of testing on mathematics education; standards and indicators of excellence in mathematics education; professional education of mathematics teachers; implications for the United States of international studies of mathematics education; and mathematical sciences curricula.

The work products that will come from the Board will be useful:

- To state legislators who seek assistance in setting standards for mathematics education;
- To classroom teachers who need information about classroom instruction in mathematics, and who seek development opportunities to improve their own teaching capabilities;
- To parents who want to help improve the quality of their local school system, but often lack the resources and support to do so;

- To business and industry who recognize that today's student is tomorrow's employee, and who seek avenues to assist in the education of students and support of teachers.

These are a few ways in which the Board can be of practical assistance to the mathematics education infrastructure.

It is important to note that the Board's activities are not a collection of individual projects. They are much more than that. A critical function of the Board will be to coordinate and synthesize its activities in testing, standards, curricula, and so forth. In this way, the Board's efforts will begin to address some of the issues that have fallen between the cracks in the 'single project' approach to mathematics education.

It is envisioned that the Board will provide coordination and continuity by working with the broad base of its membership. The Board is a unit through which the greater mathematical education partnership can act and react to bring about sustained improvement and continuous quality in mathematics education.

RECOMMENDATION: The Joint Policy Board for Mathematics recommends that the Senate Labor and Human Resources Committee monitor the progress of the Mathematical Sciences Education Board. This can be done through direct contact

with the Board [6] or through the Committee's oversight of the National Science Foundation, which is a primary source of federal funding for the Board. The Joint Policy Board believes that the Mathematical Sciences Education Board is a unique undertaking of national significance. The Board's emphasis on partnerships distinguishes it from other national efforts that are developed by only one community or designed to address only one issue. The Board is a partnership of effort among several groups and a partnership of intellect linking several issues critical to mathematics education.

HIGH SCHOOL STUDENTS OF OUTSTANDING CAPABILITY

In addition to the concern expressed above for strengthening mathematics education for all students, the Joint Policy Board for Mathematics has a special interest in students who demonstrate outstanding mathematical ability. Each year the National High School Mathematics Examination system identifies the best mathematics students in grades 9-12 through a series of nation-wide competitive examinations. Approximately 600,000 students take the first stage exams. Eventually the top 25 students are invited to a three-week training session, and five

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6. The Mathematical Sciences Education Board is chaired by Dr. Shirley A. Hill, Professor of Mathematics and Education at the University of Missouri in Kansas City. Dr. Marcia Peterson Sward is Executive Director of the Board. The Board offices are located at the National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C.

students then represent the United States in the International Mathematics Olympiad.

The effectiveness of this screening and training process is attested to by the record of the United States in the International Mathematics Olympiad: in 8 of the last 10 years the U.S. team has placed in the top three, twice coming in first.

However, no support structure currently exists to enhance the mathematical education of the thousands of students who demonstrate truly superior mathematical talent by their high scores on this examination. By not following-up with appropriate support programs, we waste precious national resources.

> RECOMMENDATION: The Joint Policy Board for Mathematics recommends the establishment by the National Science Foundation of summer training institutes in each state for students who have achieved outstanding scores on the national mathematics high school tests (or other comparable measures). These institutes would be offered by schools, colleges or universities and staffed by teachers with experience in teaching mathematics and mathematical problem solving to extremely talented students, typically the top 1-2 percent of the students in each state.

The program could be administered by the National Science Foundation by asking for competitive proposals from educational institutions in each state, or it could be administered under the jurisdiction of the Committee on American Mathematics Competitions, the committee of the Mathematical Association of America that administers the national high school examinations. Such a summer institute program could be administered annually in every state for a total of $3-5 million. Total outreach would be 2,500 students annually.

Such a program would provide important support for the continuing development of high-performing young people. This effort is necessary if we hope to replentish the mathematics manpower base.

B. UNDERGRADUATE MATHEMATICS EDUCATION

The relations between mathematics and science have always been close. But because computers make possible mathematical analysis of many scientific and engineering processes, these relations are now both more pervasive and more significant than ever before. Whereas in the past only theoretical science required advanced mathematics, today all science-based fields use sophisticated mathematical models.

This suggests a fact that is important for the undergraduate curriculum: Mathematics is changing dramatically in content, in scope and in application; it is not only being applied, but is being continually created.

Collegiate mathematics stands at the interface of educational and research issues in mathematical sciences. The mathematics faculties of our colleges must provide courses for:

- future scientists and engineers,
- prospective elementary and secondary school teachers,
- strong majors for those intending to enter graduate school,
- remedial courses for those entering college unprepared in mathematics,
- general education courses for students not majoring in a scientific discipline, and
- a variety of service courses ranging from elementary statistics to advanced operations research.

Moreover, in most institutions, mathematicians also teach some computer programming and elementary computer science.

SIGNS OF STRESS IN OUR COLLEGES

The future quality of our nation's science and technology depends on the ability of today's mathematics faculties to meet these diverse obligations. Exciting developments in the mathematical sciences resonate with creative ideas for curriculum innovation to provide challenging opportunities in undergraduate mathematics. Yet the record of the recent past suggests that our mathematics faculties are under great stress, and are increasingly unable to meet national needs in collegiate mathematics.

The following statistics attach some quantifiable measure to that stress:

o Demand for undergraduate mathematics courses has doubled since 1970, but during that same period the nation's college mathematics faculty has increased by only about 50 percent.

o Each term three million students receive mathematics instruction from about 30,000 faculty members. Despite this record demand for mathematics courses, the number of students majoring in mathematics has declined by over 50 percent and advanced (i.e., post-calculus) enrollments have declined from 20 percent to 5 percent of mathematics enrollments.

o Approximately three quarters of all mathematics credits awarded by colleges and universities are for courses more appropriate to the secondary school curriculum.

Other signs of stress are harder to quantify, but no less real. Mathematics departments, with few exceptions, do not have adequate access to computing resources that are appropriate to the actual use of mathematics in today's scientific and industrial world. As a consequence, computing has had very little impact on the mathematics curriculum--neither on what should be taught nor on how it is taught. In this age, undergraduate mathematics needs to be conducted in active symbiosis with powerful computers--for symbolic manipulation, for graphical display, for numerical analysis and for simulation.

RENEWAL OF COLLEGIATE MATHEMATICS

Inevitably, the availability of computers and the demand for new applications compels us to rethink priorities for mathematics education at all levels. To prepare students adequately for their careers in the twenty-first century, undergraduate mathematics programs must include core principles of computer science (algorithms, data structures, complexity theory); a contemporary view of numerical methods and approximation techniques; robust, computer-intensive statistical methods; graphical techniques for exploratory data analysis; and computer algorithms for optimization problems.

Unfortunately, in far too many departments, mathematics courses are dated both in spirit and in content--primarily because faculty have not had sufficient opportunity for professional development.

> RECOMMENDATION: Revitalization of undergraduate mathematics will require programs in colleges across the country that are closely linked to the frontiers of pure and applied mathematics. The key to revitalization of collegiate mathematics is a faculty that is intellectually alive. What matters most is that the faculty develop an environment in which students can encounter mathematics as a living, growing discipline.
>
> **The Joint Policy Board for Mathematics recommends that the National Science Foundation establish a program of competitive Faculty Fellowships sufficient in number to invite large numbers of applicants and sufficiently varied in purpose to promote a wide variety of accomplishment: curriculum development, student projects, professional travel, research support, computer needs. Such fellowships should be specifically targeted for projects that seek the improvement of undergraduate education. They would make a major impact on professional development of the collegiate mathematics faculty across the nation.**

The mathematics community itself has recognized the need for coordinated action to address the basic issues in mathematics education. The creation of the Mathematical Sciences Education Board at the National Research Council grew out of this recognition. The mathematics community has also presented to the National Research Council a proposal that the Mathematical Sciences Education Board and the Board on Mathematical Sciences [7] jointly undertake an in-depth review of the nation's collegiate mathematics enterprise. Out of this should come other recommendations for improving collegiate mathematics, including recommendations concerning roles for the National Science Foundation, the mathematical community, the nation's colleges, business and industry appropriate in this era of fiscal stringency.

II. MATHEMATICAL RESEARCH

It is well understood that such important goals as national security, economic strength, and the quality of life are increasingly linked to our success in introducing new technologies that have been made possible by recent scientific advances. It is less fully appreciated that scientific progress is stimulated by advances in mathematics, which defines the foundations of the sciences.

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[7] The National Research Council established the Board on Mathematical Sciences in December, 1983. The program of the Board on Mathematical Sciences is designed primarily to undertake studies involving pure mathematics, applied mathematics, and statistics.

A few years ago the National Research Council established an ad hoc Committee on Resources for the Mathematical Sciences to look into the health and support of fundamental mathematics research in the United States. The ad hoc Committee, chaired by Dr. Edward E. David, Jr., former science advisor to the president and then-president of Exxon Research and Engineering Company, found support for mathematical research in an alarming state--hence the title of its report, Renewing U.S. Mathematics: Critical Resource for the Future [8].

KEY FINDINGS OF THE AD HOC COMMITTEE

The most significant finding of the Committee will not seem novel. But it goes far toward explaining how mathematics funding came to its present state: There is today a widespread misunderstanding and under-appreciation of the role of mathematics in scientific and technological progress.

Even among sophisticated observers of science and technology, there is a tendency to believe that the necessary mathematics already exists and needs only to be applied. That

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8. This report was published by the National Academy Press, Washington, D.C., June, 1984.

the creation of new mathematics is a vital part of scientific and technological advancement often escapes attention.

New mathematics is central to the design of high density integrated circuits, the design of information networks, and the design of solution procedures without which even our fastest computers would be ineffective.

It is used in advanced technologies for finding oil, for enhancing production from existing oil fields, and for creating new chemical and oil refining processes. It is vital to the defense effort, and it will become more so, particularly in such ambitious undertakings as the Strategic Defense Initiative.

The point is that mathematics research is essential to progress in many scientific and engineering disciplines. And the outlook is for this to be so for more and more fields, a trend being accelerated by parallel advances in instrumentation and computing.

SPECIFIC FINDINGS OF AD HOC COMMITTEE

What did the ad hoc Committee find about the state of mathematics? What did it recommend? What has happened since the report was issued twenty-two months ago?

The specific findings of the ad hoc Committee can be summarized as follows:

- Constant dollar federal support for mathematics research declined by over 33 percent in the fifteen year span from 1968-1972;

- This has left mathematics research support markedly out of balance with support for related fields of science and technology;

- Given the central role mathematics plays in all these fields, this imbalance will seriously weaken the nation's technological effort unless it is corrected. Clear signs of its negative impact on university mathematics centers abound;

- It will require an additional federal investment of at least $100 million per year (in 1984 dollars) to restore balance. This increase should be accomplished over a three-to-five year period.

HOW BAD IS THE IMBALANCE?

The chart in Appendix II provides a comparison of federal support in institutions of higher education for three fields of science in 1980. These figures make manifestly clear the kinds of imbalances that had developed between mathematics and other fields of research by the start of this decade:

- There were just as many mathematicians in colleges and universities in the United States as physicists or chemists. Yet only about two-thirds as many mathematics faculty received federal research support.

- Only a small percentage of the graduate students were federally supported, as compared to large percentages in chemistry and physics.

- And look at the postdocs--50 in mathematics, compared to 1,200 in physics and 2,500 in chemistry!

HOW DID SUCH AN IMBALANCE COME ABOUT?

The ad hoc Committee's report gives a thorough explanation of the historical events which led to the existing imbalance between support for mathematics research and support for related fields of science and engineering. There were three critical events:

- Mathematics research support has long been heavily concentrated in just two federal agencies -- the Department of Defense (DOD) and the National Science

Foundation. When the Mansfield Amendment and its pre- and after-effects caused DOD to drop nearly all its support for core mathematics research in the late 1960's and early 1970's, the NSF did not take up any of the slack.

- When dramatic reductions in federal science fellowships occurred in the early 1970's, no compensating increase occurred at the NSF in research assistantships for graduate students in mathematics, as happened in other fields of science.

- After these two events, in which one-third of the constant dollar support of the mathematics research enterprise was eliminated, the NSF and DOD budgets for mathematics stayed flat (in constant dollars) for the decade 1973-1982. This fact largely escaped notice because mathematics was lumped together with computer science in federal data. In the aggregate figures, rapid growth in computer science masked the flat support for basic mathematics.

AD HOC COMMITTEE RECOMMENDATIONS

To begin correcting this situation, Renewing U.S. Mathematics: Critical Resource for the Future makes some conservative recommendations -- even though it did call for more than a doubling of support over five years. The increases would come from a low base -- from $80 million per year in 1984 (in 1984 dollars) to $180 million per year (in 1984 dollars) at the close of five years.

PROGRESS IN RECENT YEARS

In an unprecedented action taken in December, 1984, the National Science Board (NSB) formally commended the ad hoc Committee for its "timely and compelling report." Furthermore, the NSB noted the importance of balance in support for scientific and engineering disciplines, "especially where a specific field, such as the mathematical sciences, affects much of the scientific, engineering and technological enterprise of the nation." It then adopted this resolution:

> RESOLVED, that a concerted effort should be made by all funding agencies to increase support for the mathematical sciences for several years until a proper level of sustaining support has been achieved.

In the last three years there has been important, but still insufficient, progress toward meeting the goal of restoring balance.

At the National Science Foundation, the effort began early in 1983 and has continued under the determined leadership of Erich

Bloch. His most recent act was to obtain approval for reprogramming which exempted mathematics from the fiscal year 1986 Gramm-Rudman-Hollings budget cuts. The foci for renewal at the Foundation have been:

- o Increased support for graduate students and postdoctorals, to address the severe manpower problems which mathematics now faces;

- o Increased emphasis on computational mathematics.

The National Science Foundation is now supporting over 600 graduate students and 200 postdocs in mathematics, as contrasted with numbers which were almost zero a few years ago. These figures still pale beside analogous figures for physics or chemistry, but there is progress.

A major initiative in computational science and engineering has been started at the National Science Foundation, with an important role for computational mathematics. The Joint Policy Board for Mathematics supports the initiative and has a strong interest in continuing a dialogue with Congress as well as the National Science Foundation about the evolution of the initiative.

At the Department of Defense, which together with the National Science Foundation accounts for 94 percent of federal support for mathematics research, increases in each of fiscal years 1984 and 1985 of roughly 10 percent were to have been followed in fiscal year 1986 with a 30 percent increase. A significant part of this projected fiscal year 1986 increase was the addition of a new mathematics program at the Defense Advanced Research Projects Agency (DARPA).

The Gramm-Rudman-Hollings budget cuts will reduce the projected fiscal year 1986 increase of 30 percent to 10 percent, which will have the effect of reducing the numbers of individual research grants at the military service agencies. This will be the result even if the Department of Defense's University Research Initiative and Strategic Defense Initiative offset part of the reduction.

FEDERAL SUPPORT: SHORTFALL IN PRESENT LEVELS

The chart in Appendix III shows the total federal support for mathematical research at $90.5 million in fiscal year 1985, the last year for which there are firm numbers. Fiscal year 1986 appropriations totalled $105 million before the impact from Gramm-Rudman-Hollings was felt at agencies other than the National Science Foundation.

Allowing for inflation, federal support for mathematics is still more than $90 million (in 1986 dollars) short of the support levels recommended by the National Research Council's ad hoc Committee. Support has been growing, but at only about half the rate necessary. Next year at this time, a more detailed assessment of what has been achieved in terms of balance between support for mathematics and support for related fields should be possible.

MATHEMATICS MANPOWER PROBLEM

We do know that the manpower situation in mathematics is actually worse than it was two or three years ago. Ph.D. production has dropped again, from about 800 per year to about 750 per year. There is an annual shortfall of about 150 Ph.D.'s available to fill full-time faculty positions at the four-year institutions. As existing faculty age, retirement rates are accelerating. Demands for sophisticated computational applied mathematicians are rising sharply.

This does not bide well for renewal of the field, but there are signs of hope. Preliminary data of the undergraduate survey conducted every five years by the Conference Board of the Mathematical Sciences show that the number of undergraduate mathematics majors is on the upswing again. If the effort to increase support for graduate students and postdoctorals is continued in the years ahead, we should be able to attract and develop the talent necessary to renew the country's mathematical research effort.

RECOMMENDATION: The Joint Policy Board for Mathematics urges the Committee on Labor and Human Resources to support and augment the increases in mathematics funding being undertaken by the National Science Foundation. Mathematics is a foundation discipline. This means that mathematics should be central to deliberations about science policy. When setting priorities and authorizing funds for science and technology, the Congress should ask what portion of those funds supports the foundation discipline, mathematics. Congressional support is essential if we are to restore this vital field to health in the next decade.

RECOMMENDATION: In view of the fact that the National Science Foundation and the Department of Defense account for 94 percent of federal support for research in the mathematical sciences, and thereby share responsibility for the future health of mathematical research, the Joint Policy Board for Mathematics recommends that the Senate Committees on Labor and Human Resources and Armed Services conduct joint oversight hearings on federal support for mathematical research. Such hearings could (1): assess progress in restoring balance between federal support for mathematical research as compared to other scientific disciplines; and (2) determine whether proposed levels of support in future budgets of the National Science Foundation and the Department of Defense continue that progress.

The Joint Policy Board for Mathematics appreciates the opportunity to present testimony before the Committee on Labor and Human Resources.

Appendix I

THE MATHEMATICAL SCIENCES EDUCATION BOARD

DR. SHIRLEY A. HILL, Chairman MAA, NCTM, AMS, AAUP, ASL*
Professor of Mathematics & Education
University of Missouri-Kansas City

Shirley Hill has an extensive background in mathematics and education. She has taught in the public schools and at the university level. Dr. Hill's experience as a national leader in mathematics education and knowledge of grass roots problems in mathematics instruction bring a unique combination of strengths to the leadership activities of the Mathematical Sciences Education Board of the National Research Council.

MR. GORDON M. AMBACH CCSSO
Commissioner of Education
State Education Department
State of New York

Gordon Ambach is the 1984 - 85 president of the Council of Chief State School Officers, and has served as Commissioner of Education in New York State since 1977. Mr. Ambach's long involvement in educational activities as a teacher and in educational governance and policy lends a solid view of the problems and needs in mathematics instruction from the perspective of the state educational agency.

DR. J. MYRON ATKIN AAAS, AAUP, CESI, AERA, NARST
Dean, School of Education
Stanford University

Myron Atkin has degrees in science education and chemistry, and has participated extensively for several years in science education policy development at the national and international levels. Recently, he has been active on the Task Force on the Teaching Profession of the Committee for Economic Development, the Advisory Committee for Science and Engineering Education of the National Science Foundation, and the National Panel on the High Schools of the Carnegie Foundation for the Advancement of Teaching.

DR. DAVID BLACKWELL IMS, ASA, AMS, AAAS, NAS
Professor of Statistics
University of California-Berkeley

David Blackwell is a research mathematician whose work is concentrated in probability and statistics. He is a member of the National Academy of Sciences and has received the ORSA-TIMS von Neumann Theory Prize. Dr. Blackwell has held positions of leadership in several mathematics and statistics professional associations.

MS. GAIL F. BURRILL NCTM, NCSM
Chair, Department of Mathematics
Whitnall High School
Greenfield, Wisconsin

Gail Burrill teaches mathematics in the urban Whitnall School District, where she has taught grades 5 - 12. Ms. Burrill is a recipient of the 1985 Presidential Award for Excellence in Mathematics Teaching. She has participated in the Woodrow Wilson National Teaching Fellowship Foundation Institute on High School Mathematics, the General Electric Teacher Award Program, and the Woodrow Wilson Master Teacher Program. Ms. Burrill is active in several local professional mathematics associations.

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*Please refer to the acronym index at the end of this listing for identification of association memberships.

MRS. IRIS M. CARL NCTM, NCSM
Elementary Mathematics Instructional Supervisor
Houston Independent School District
Houston, Texas

Iris Carl is the mathematics instructional supervisor for 18 elementary schools in the Houston Independent School District. She holds leadership positions in the National Council of Teachers of Mathematics and the National Council of Supervisors of Mathematics. She is a member of Phi Delta Kappa.

DR. C. HERBERT CLEMENS AMS, MSC
Professor of Mathematics
University of Utah

Herbert Clemens is a research mathematician whose professional activities, in addition to his distinguished mathematical research at the University of Utah, have included assistance to local school districts in mathematics instruction and work in international mathematics education. Recently, he was an invited speaker at the quadrennial International Congress of Mathematicians. He is a member of the Committee on Mathematics of the National Research Council's Board on Mathematical Sciences.

MR. CLYDE L. CORCORAN NCTM, NEA, MAA
Mathematics Teacher
California High School
Whittier, California

Clyde Corcoran holds degrees in mathematics and education, and is a high school mathematics teacher in suburban Whittier, California. He was a 1983 recipient of the Presidential Award for Excellence in Mathematics Teaching. Mr. Corcoran is very active in local and state chapters of national professional mathematics and education associations.

DR. F. JOE CROSSWHITE NCTM, CSSP, CBMS, MAA, AERA
President
National Council of Teachers of Mathematics
Reston, Virginia

Joe Crosswhite has extensive experience in mathematics education, both as a college professor and a leader in mathematics teaching associations. As president of the National Council of Teachers of Mathematics, he has exercised strong leadership during a period when national concern focused on the quality of mathematics instruction in elementary and secondary schools.

MR. RICHARD de AGUERO NCTM
Director of Student Activities
Miami Senior High School
Miami, Florida

Richard de Aguero has taught high school mathematics in the urban Dade County Public School system, and received the South Florida Teacher of the Year Award in 1976. He has been active in the local chapters of several national mathematics teacher associations, was a member of Florida's Committee on Teacher Education, and received the 1985 Mathematics Educator of the Year award from the Florida Council of Teachers of Mathematics.

MR. WILLIAM J. DENNIS, JR.
Senior Research Fellow
Research and Education Foundation
National Federation of Independent Business, Inc.
Washington, District of Columbia

William Dennis has been with the National Federation of Independent Business — the largest association representing small and independent businesses — for the past ten years. Presently, he is serving as Senior Research Fellow for the NFIB's Research and Education Foundation. His involvements with education include membership on the committee known as the "Heckert Panel," which produced the 1984 National Research Council report, High Schools and the Changing Workplace: The Employers' View.

DR. JOHN A. DOSSEY MAA, NCTM,
Professor of Mathematics CBMS, CSSP
Illinois State University

John Dossey has a degree in mathematics education and has provided mathematics instruction to students at the middle school, high school, and university levels. He received the Max Beberman Award for outstanding contributions to mathematics education in Illinois and the James Armstrong Award for outstanding contributions to community college mathematics in Illinois. He is president-elect of the National Council of Teachers of Mathematics.

DR. JAMES T. FEY NCTM, MAA, AERA
Professor of Curriculum & Instruction
and Mathematics
University of Maryland

James Fey holds a degree in mathematics education, and has been deeply involved in mathematics and mathematics education projects at all levels of learning. Dr. Fey is well known in the mathematics community for his understanding of the use of computers in education, particularly in the mathematics curriculum.

DR. ROBERT GLASER AAAS, AERA, APA,
Co-Director, Learning Research & NSSE, NCME, SRCD
Development Center
University of Pittsburgh

Robert Glaser is well known for his work in cognitive research and development. He is president of the National Academy of Education and has received many awards for contributions to his field, including the American Educational Research Association's award for Distinguished Research in Education.

MR. ANDREW M. GLEASON AMS, MAA,
Hollis Professor of Mathematicks and Natural Philosophy NAS
Harvard University

Andrew Gleason is a distinguished research mathematician, and a member of the National Academy of Sciences. He was president of the American Mathematical Society, and is chairman of the Steering Committee for the Twenty-First International Congress of Mathematicians, which will take place in 1986.

BROTHER NEAL GOLDEN NCTM
Chairman, Computer Science Department
Brother Martin High School
New Orleans, Louisiana

Neal Golden is a mathematician who teaches mathematics and computer science in an urban New Orleans high school, where he is also chairman of the computer science department. He has written several high school mathematics and computer textbooks. Brother Golden is a member of the Technology Advisory Committee of the National Council of Teachers of Mathematics.

HONORABLE GENE HOFFMAN NCSL, ECS
State Representative
Illinois House of Representatives

Gene Hoffman is a member of the Illinois General Assembly, where he now serves as Assistant Minority Leader. He is past chairman of the Illinois School Problems Commission and a member of the Illinois

Commission on the Improvement of Elementary and Secondary Education, a product of which was the 1985 Illinois education reform law. Dr. Hoffman is past chairman of the Education and Labor Committee of the National Conference of State Legislatures, and now serves as commissioner from Illinois to the Education Commission of the States.

DR. KENNETH M. HOFFMAN
Professor of Mathematics
Massachusetts Institute of Technology
AMS, AAAS, MAA, SIAM, NCTM, ASA, ORSA

Kenneth Hoffman is a research mathematician and author of several widely-used textbooks. He served as head of the Mathematics Department at MIT and most recently has worked with mathematics policy at the federal level, particularly in the development of the "David Report," Renewing U.S. Mathematics: Critical Resource for the Future, and as Chairman of the National Science Foundation's Advisory Committee for Science Education.

DR. JOSEPH R. HOFFMANN
Consultant in Mathematics Education
California State Department of Education
NCTM, AERA, NEA, USMA, ASSM, NCSM, MAA

Joseph Hoffmann, whose degree is in mathematics education, works at the state level to improve the mathematics education program in close to 8,000 schools in California. He has done extensive work in testing and evaluation, and curriculum research projects, including the math framework for California schools and the California assessment program. Dr. Hoffmann is president of the Association of State Supervisors of Mathematics.

MR. DAVID R. JOHNSON
Chairman, Mathematics Department
Nicolet High School
Glendale, Wisconsin
NCTM, NCSM

David Johnson teaches mathematics in suburban Nicolet High School, where he is also an administrator involved with supervision of mathematics and science personnel and coordination of curriculum, grades 7 - 12. He was a 1983 recipient of the Presidential Award for Excellence in Mathematics Teaching. He is an active member and leader in many national professional mathematics organizations and their local chapters. Mr. Johnson is also a member of Phi Delta Kappa, and president of the National Council of Supervisors of Mathematics.

MRS. ANN P. KAHN
President, The National Congress
of Parents and Teachers
Chicago, Illinois
PTA, ASCD

Ann Kahn has been active in education concerns at the local, state, and national levels. As a member of the Fairfax (Virginia) County School Board, she chaired committees on instruction, gifted and talented, and student responsibilities and rights. Mrs. Kahn has served on advisory panels and review committees for the National Institute of Education and the National Science Foundation.

DR. JEREMY KILPATRICK
Professor of Mathematics Education
University of Georgia
MAA, NCTM, AERA, IGPME, NCME, CB

Jeremy Kilpatrick is well known for his research in mathematics education. He was the plenary speaker for the Fifth International Congress on Mathematics Education and the Fifth Conference on Psychology of Mathematics Education. Recently, he delivered the John Wilson Memorial Address to the Research Council for Diagnostic and Prescriptive Mathematics. Dr. Kilpatrick is the editor of the Journal for Research in Mathematics Education.

DR. JOAN R. LEITZEL AMS, MAA, AAAS, AWM
Professor of Mathematics and
Associate Provost
The Ohio State University

Joan Leitzel is a professor of mathematics who was recognized with the Ohio State Alumni Award for Distinguished Teaching and the Rosaline Sedgewick Award for Teaching Service in Arts and Sciences. She is a university administrator and active in several national associations, including the Mathematical Association of America and the Association for Women in Mathematics.

MRS. PEGGY C. NEAL NCTM, NEA
Mathematics Teacher
Burney Harris Lyons Middle School
Athens, Georgia

Peggy Neal is a middle school teacher of mathematics in the urban Clarke County School District. Recently, she received the Gladys M. Thomason Award for Excellence in Mathematics in Georgia, was the Athens Woman of the Year in Education, and was state finalist for the Presidential Awards for Excellence in Mathematics Teaching. Mrs. Neal is an officer in both Phi Delta Kappa and Delta Kappa Gamma, and is an active member of national and local mathematics and education associations.

DR. HENRY O. POLLAK MAA, AMS
Assistant Vice President
Mathematical, Communications & Computer
Sciences Research Laboratory
Bell Communications Research

Henry Pollak is an industrial research mathematician who has contributed greatly throughout the years to the efforts of the professional mathematics community to strengthen mathematics education. He has served in many leadership positions, including chairman of the Conference Board of the Mathematical Sciences and chairman of the National Science Foundation's Advisory Committee on Science and Engineering Education.

DR. JACK PRICE NCTM, AAAS, AASA
Superintendent of Schools
Palos Verdes Peninsula Unified
School District
Palos Verdes, California

Jack Price holds degrees in mathematics education, curriculum development, chemistry, and mathematics. He is superintendent of eight elementary, four middle, and four high schools in southern California. Dr. Price is a well-known mathematics textbook author, who has been very active in mathematics education.

DR. ANTHONY RALSTON ACM, AFIPS, MAA, SIAM
Professor of Computer Science
State University of New York
at Buffalo

Anthony Ralston moved from his doctorate in mathematics to work in industry (Bell Labs, American Cyanamid), and then to the academic world. His career encompasses teaching, research in programming languages and in computer science education, and administration. He has been president of both the Association for Computing Machinery and the American Federation of Information Processing Societies, and has served on the Computer Science and Technology Board of the National Research Council.

DR. STEPHEN B. RODI
Division Chairperson
Mathematics & Physical Sciences
Austin Community College

AMATYC, MAA,
CBMS,
COMAP, NCTM

Stephen Rodi is a mathematics professor and administrator, and is a leader in national efforts to enhance mathematics instruction in community colleges. He was the Piper Nominee for the Outstanding Teacher in Texas. Dr. Rodi is president of the American Mathematical Association of Two Year Colleges.

MR. FREDERICK A. ROESCH
Senior Vice President, Global
Electronic Marketing
Citibank, N.A.
New York, New York

Frederick Roesch heads global electronic markets activities for the institutional bank sector of Citicorp. He joined Citibank in 1964 and headed Thailand operations, world-wide venture capital activities, and Citicorp personnel planning and development before assuming his present position in 1985. He was a member of the committee known as the "Heckert Panel," which produced the 1984 National Research Council report, High Schools and the Changing Workplace: The Employers' View.

DR. PAUL J. SALLY
Professor of Mathematics
The University of Chicago

MAA, AMS

Paul Sally is a research mathematician and professor, who has received the Quantrell Award for Undergraduate Teaching from The University of Chicago. Dr. Sally was chairman of the committee of the Conference Board of the Mathematical Sciences which developed the initial proposal for the Mathematical Sciences Education Board. He is also Director of The University of Chicago's School Mathematics Project, funded by AMOCO.

DR. C. THOMAS SCIANCE
Director, Engineering Research
E. I. du Pont de Nemours & Co.
Wilmington, Delaware

ACS, AICE

Thomas Sciance is a chemical engineer who manages the activities of both the Engineering Technology Laboratory and the Engineering Physics Laboratory at du Pont's Experimental Station in Wilmington. He is a member of the advisory boards for the engineering schools at Duke and Rice Universities, and the advisory committees on chemical engineering at the University of Oklahoma and Texas A&M. Recently, he has served on an industrial committee at the University of Texas, which has just completed a major review of the future of chemical engineering education.

DR. LYNN ARTHUR STEEN
Professor of Mathematics
St. Olaf College

MAA, CSSP, AAAS,
AMS, COMAP,
CBMS, JPBM

Lynn Steen is a national leader in undergraduate mathematics education and related policy issues. A prolific and talented writer, Dr. Steen has received on two occasions the Lester R. Ford Award for Expository Writing in mathematics. He is president of the Mathematical Association of America.

DR. DOROTHY S. STRONG
Director of Mathematics
Chicago Public Schools
Chicago, Illinois

NCTM, NCSM,
NABSE, ASCD

Dorothy Strong supervises the mathematics program in the 560 schools of the Chicago Public School system. She is a member of Kappa Delta Pi and Kappa Mu Epsilon, and has been awarded the Education Pace Setter Award. Dr. Strong is active in several professional associations, including the Association of Supervision and Curriculum Development.

DR. CALVIN J. WOLFBERG NSBA
President
Pennsylvania School Board Association

Calvin Wolfberg is a practicing optometrist in Northumberland, Pennsylvania, where he is also active as president of the Pennsylvania School Board Association. Dr. Wolfberg brings to the Mathematical Sciences Education Board a broad-based understanding of the educational enterprise at the local level.

DR. MORRIS DeGROOT AAAS, ASA,
Professor of Statistics IMS, ISI
Carnegie-Mellon University
(Liaison Member, representing the National Research Council's Commission on Behavioral and Social Sciences and Education)

Morris DeGroot is a research statistician who has been active in the National Research Council's Committee on National Statistics, as well as in the NRC Assembly which evolved into the Commission on Behavioral and Social Sciences and Education. He is a fellow of the Royal Statistical Society and now serves on the Advisory Committee for Mathematical Sciences of the National Science Foundation.

DR. HIRSH G. COHEN SIAM, AMS
Vice President, Divisional Operations
IBM Research
T. J. Watson Research Center
Yorktown Heights, New York
(Liaison Member, representing the National Research Council's Commission on Physical Sciences, Mathematics & Resources)

Hirsh Cohen is an industrial mathematician and leader in the national mathematics community. He is past-president of the Society for Industrial and Applied Mathematics, and is a member of the National Research Council's Board on Mathematical Sciences.

ACRONYM INDEX

AAAS	American Association for the Advancement of Science
AAUP	American Association of University Professors
ACM	Association for Computing Machinery
ACS	American Chemical Society
AERA	American Educational Research Association
AFIPS	American Federation of Information Processing Societies
AICE	American Institute of Chemical Engineering
AMATYC	American Mathematical Association of Two Year Colleges
AMS	American Mathematical Society
APA	American Psychological Association
ASA	American Statistical Association
ASCD	Association of Supervision and Curriculum Development
ASL	Association for Symbolic Logic
ASSM	Association of State Supervisors of Mathematics
AWM	Association for Women in Mathematics
CB	The College Board
CBMS	Conference Board of the Mathematical Sciences
CCSSO	Council of Chief State School Officers
CESI	Council for Elementary Science International
COMAP	Consortium for Mathematics and Its Applications
CSSP	Council of Scientific Society Presidents
ECS	Education Commission of the States
IGPME	International Group for the Psychology of Mathematics Education
IMS	Institute of Mathematical Statistics
ISI	International Statistics Institute
JPBM	Joint Policy Board for Mathematics
MAA	Mathematical Association of America
NARST	National Association for Research in Science Teaching
NAS	National Academy of Sciences
NABSE	National Alliance of Black School Educators
NCME	National Council on Measurement in Education
NCSL	National Conference of State Legislatures
NCSM	National Council of Supervisors of Mathematics
NCTM	National Council of Teachers of Mathematics
NSSE	National Society for the Study of Education
NEA	National Education Association
NRC	National Research Council
NSBA	National School Boards Association
ORSA	Operations Research Society of America
SIAM	Society for Industrial and Applied Mathematics
SRCD	Society for Research in Child Development
USMA	United States Metric Association

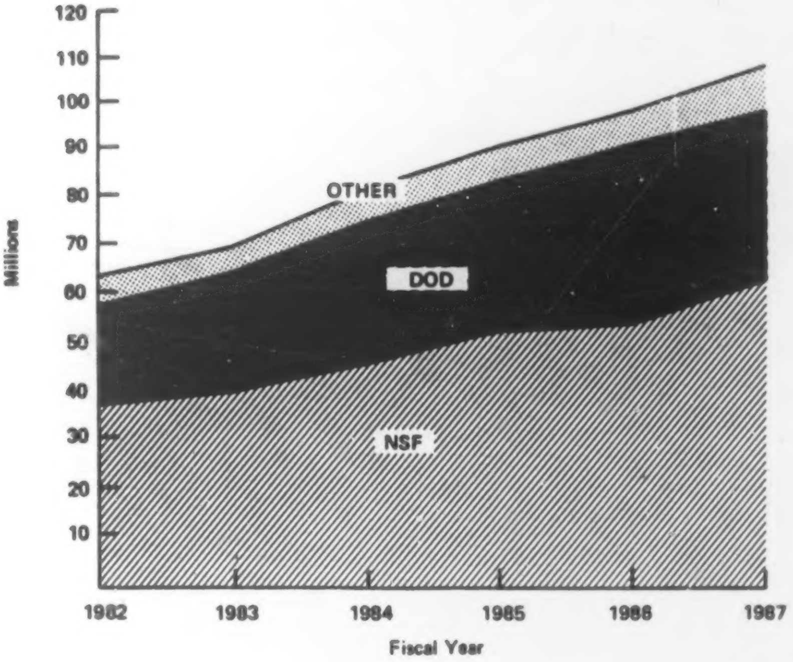
Comparisons of Federal Support in Institutions of Higher Education for Three Fields of Science, 1980

	Chemistry	Physics	Mathematical Sciences
Doctoral scientists in R&D	9,800	9,200	9,100
Faculty with primary or secondary activity in R&D	7,600	6,000	8,400
Faculty in R&D federally-supported	3,300	3,300	2,300
Approximate annual Ph.D. production	1,500	800	800
Graduate research assistants federally-supported	3,700	2,900	200
Postdoctorals federally-supported	2,500	1,200	50

Sources: NRC Survey of Doctoral Recipients,
National Science Board--Status of Science Review

Appendix III

Federal Support of Basic Academic Research in Mathematical Sciences



Federal Support of Basic Academic Research in Mathematical Sciences (FY)

	82	83	84	85	86 3)	87 4)
NSF 1)	34.2	37.1	45.6	52.7	57.2	65.5
DOD 2) (AFOSR, ARO, ONR, DARPA)	23.3	26.5	29.9	32.3	42.4	39.1
Other 2) (DOE, NASA, NIH)	4.3	4.8	4.9	5.5	5.9	4.8
Total	61.8	68.4	80.4	90.5	105.5	109.4

1) DMS represents about 90%.
2) This is based on estimates of the mathematics extramural.component of some programs.
3) These are pre Gramm-Rudman, SDI and University Research Initiative figures. Their eventual effects may cancel each other.
4) The President's budget. Estimates of ultimate program emphasis (see 2) and future effects of URI and SDI make these tentative, especially outside NSF.

Mr. **CHAIRMAN**. We appreciate your appearance here today, Mr. Bloch, and we appreciate the preparation that you have put into your testimony. We are grateful to have had you here.

Do you have any other questions, Senator Pell?

Senator **PELL**. No, Mr. Chairman.

The **CHAIRMAN**. With that, we will recess until further notice.

[Whereupon, at 10:40 a.m., the committee was adjourned.]

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